



Learner Centric Advanced Manufacturing Platform

# D5.4 Report: Integrated Learning Pathways Tool for Lifelong Learning

WPN° 5 Learner-Centric Training



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# GLOSSARY AND/OR ACRONYMS

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**AI** – Artificial Intelligence  
**AM** – Advanced Manufacturing  
**API** – Application Programming Interface  
**CAD** – Computer-Aided Design  
**CEDEFOP** – European Centre for the Development of Vocational Training  
**CNC** – Computer Numerical Control  
**CoVE** – Centre of Vocational Excellence  
**CV** – Curriculum Vitae  
**DHBW** – Duale Hochschule Baden-Württemberg  
**EDC** – European Digital Credential  
**ECTS** – European Credit Transfer and Accumulation System  
**ELM** – European Learning Model  
**EQF** – European Qualifications Framework  
**ESCO** – European Skills, Competences, Qualifications and Occupations  
**EU** – European Union  
**Europass** – European Portfolio of Skills and Qualifications  
**HVET** – Higher Vocational Education and Training  
**HR** – Human Resources  
**I4.0** – Industry 4.0  
**IoT** – Internet of Things  
**ISCO** – International Standard Classification of Occupations  
**KPI** – Key Performance Indicator  
**LCAMP** – Learner Centric Advanced Manufacturing Platform  
**LLL** – Lifelong Learning  
**MOOC** – Massive Open Online Course  
**PLC** – Programmable Logic Controller  
**QA** – Quality Assurance  
**SME** – Small and Medium-Sized Enterprise  
**UI** – User Interface  
**VET** – Vocational Education and Training  
**WP** – Work Package



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# 1. EXECUTIVE SUMMARY

This deliverable presents the Integrated Learning Pathways Tool developed within Work Package 5 (Learner-Centric Training) of the LCAMP project. The tool addresses the growing skills mismatch in the Advanced Manufacturing sector by enabling personalised, data-driven learning pathways that support lifelong learning, upskilling, and reskilling in the context of Industry 4.0 and 5.0.

Building on previous LCAMP deliverables (D5.2 Skills Assessment Toolkit and D5.3 Micro-credentials Catalogue), the tool integrates skills self-assessment, job profile matching, skills gap analysis, and targeted learning recommendations within a single digital environment. It connects individual competence profiles with industry-validated job roles and modular learning opportunities, including micro-credentials aligned with European frameworks such as EQF, ESCO, the European Learning Model (ELM), and Europass Digital Credentials.

The Integrated Learning Pathways Tool is designed for multiple user groups, including learners, workers, HR professionals, and VET/HVET providers. It supports human-centric career development, flexible transitions, and stackable learning trajectories, contributing directly to European policy priorities on lifelong learning, micro-credentials, and workforce resilience. The deliverable demonstrates how skills intelligence and digital tools can operationalise personalised learning pathways and strengthen the responsiveness of vocational education and training to labour market needs.



## 2. INTRODUCTION

Advanced manufacturing (AM) in Europe faces an urgent need to continuously train and retrain its workforce to keep pace with rapid technological change. The LCAMP deliverable 5.4, alias the Integrated Learning Pathways Tool for Lifelong Learners (LLLs) was developed as part of the LCAMP project to address these challenges by providing a holistic digital solution for creating competency profiles, planning career paths, and providing personalised learning recommendations. This tool responds directly to the gaps identified in the LCAMP needs analysis and the skills and trends observatory (WP3) – for example, that existing skills profilers do not yet offer modular learning paths with micro-credentialed learning opportunities for upskilling and reskilling. In line with EU policy objectives (e.g. the EU Skills Agenda's call to 'build a culture of lifelong learning in Europe' (**European Commission 2020**) and the Council Recommendation on Micro-Qualifications (**Council of the European Union, 2022**), which supports flexible, short learning opportunities), the tool promotes adaptable, permeable and modular learning pathways in advanced manufacturing. It was developed against the backdrop of the dual transformation (digital and green) in the context of Industry 4.0, which requires a human-centred approach to workforce development. By guiding users through tailored learning pathways that integrate micro-credentials and formal courses, the tool aims to put lifelong learning into practice and increase the employability and competitiveness of AM professionals across Europe.

### 2.1. OVERVIEW OF LCAMP AND WP5

The rapid evolution of Industry 4.0 technologies (AI, robotics, IoT) and the consolidation of the Industry 5.0 paradigm are reshaping skill requirements across Europe. A substantial proportion of the workforce is expected to require reskilling due to technological transformation, and job-related skills are evolving at an unprecedented pace. In advanced manufacturing, companies must adopt digital and green innovations to stay competitive, yet a significant proportion of European SMEs struggle to find employees with the required skills (European Commission, 2020). This skills gap threatens the competitiveness and sustainability of European industry. The Industry 5.0 vision calls for a human-centric transformation – leveraging new technology not to replace workers but to empower them with new skills and roles. In response, the EU has made skills a central strategic priority, through initiatives like the European Skills Agenda, and the European Year of Skills (**European Commission 2023**), to bridge the gap between labor market demands and workforce capabilities. One flagship approach has been establishing Centers of Vocational Excellence (CoVEs) – networks of VET institutions and industry partners that innovate in skills development. The LCAMP project (Learner-Centric Advanced Manufacturing Platform) is a CoVE initiative funded by Erasmus+ that exemplifies this effort. LCAMP's mission is to build a sustainable future for advanced manufacturing, "starting with the learner," by fostering collaboration between VET centers and companies to reduce skills mismatches. Its objectives include identifying future skills needs, enabling personalized learning paths, and recognizing micro-credentials across the sector. In this chapter, we situate LCAMP – particularly Work Package 5 (WP5): Learner-Centric Training – within the broader European VET and advanced manufacturing context. We highlight how WP5 is developing a learner-



centered ecosystem for upskilling and reskilling in Industry 4.0/5.0, aligned with European frameworks like EQF, ESCO, ELM, EDC and the EU's Skills Agenda.

## 2.2. WP5 LEARNER-CENTRIC TRAINING

WP5 of LCAMP, “Learner-Centric Training,” focuses on empowering individuals to navigate fast-changing skills demands through tailored learning opportunities. This entails four key pillars: skills profiling and gap analysis, micro-credential design and cataloguing, data-driven curriculum alignment with job profiles, and the development of this report D5.4 Integrated Learning Pathways Tool. Collectively, these actions aim to build an ecosystem where learners – whether young students, employees of SMEs, or mid-career adults – can continuously assess their competencies, identify skill gaps relative to industry needs, and pursue agile, personalized learning pathways to fill those gaps. Crucially, WP5's approach is grounded in the human-centric principles championed by Industry 5.0: it puts the learner's individual needs and context at the center of the training process, rather than a one-size-fits-all curriculum. This is especially important in advanced manufacturing, where technologies evolve rapidly; workers must frequently update their skills in areas like AI, digitalization, green technologies, and transversal “soft” skills (e.g. problem-solving, adaptability). WP5 addresses this by creating flexible learning modules (micro- and nano-credentials) that can be quickly updated and recombined, enabling continuous upskilling in a modular fashion.

**Skills profiling and gap analysis:** A foundation of WP5 is the Skills Self-Assessment Toolkit ([https://lcamp.eu/wp-content/uploads/sites/53/2024/12/D5.2\\_Skills-Assessment-Tool\\_V.1.0\\_Final\\_VotingValidation.pdf](https://lcamp.eu/wp-content/uploads/sites/53/2024/12/D5.2_Skills-Assessment-Tool_V.1.0_Final_VotingValidation.pdf)), an interactive tool that allows learners to profile their current skills against relevant competency frameworks. The self-assessment covers domains critical to Industry 4.0/5.0 – e.g. advanced manufacturing techniques, AI literacy, digital skills (DigComp; European Commission, 2022a), green skills (GreenComp; European Commission, 2022b), and transversal competences. By reflecting standardized skill statements (often aligned to frameworks like DigComp or ESCO's skill descriptions), users obtain a personal skills profile with proficiency levels. This profile is then used for gap analysis: the tool can compare the individual's proficiencies to the competencies required by specific job roles in advanced manufacturing. For this purpose, LCAMP WP5 – in collaboration with the project's Skills and Jobs Observatory – has collected and validated an extensive database of approximately 700 job profiles across partner countries. Each job profile in the database (e.g. CNC Programmer, Industrial Robotics Technician, etc.) is described in terms of the skills and knowledge required. By mapping a learner's self-assessed skills against a target job profile, the system can identify skill gaps with precision. This data-driven gap analysis is a cornerstone of “skills intelligence” in WP5 – leveraging real labor market data to inform training needs. It reflects a wider European trend of using skills intelligence systems (like CEDEFOP's Skills Panorama; Cedefop, 2024) to better align education with employment needs.. Indeed, LCAMP partners embedded labor market meta-data into the profiling process; for example, new training modules were tagged not only with their learning outcomes but also with relevant ESCO skills and insights from skills gap research (CEDEFOP and LCAMP's own observatory). This ensures that the identified gaps and suggested trainings correspond to current and emerging industry demands, making the upskilling process highly relevant.

**Micro-credential design and cataloguing:** To address identified skill gaps, WP5 developed a catalogue of micro-credentials and courses [https://lcamp.eu/wp-content/uploads/sites/53/2025/05/LCAMP-Reporting\\_D5.3\\_Database-of-I4.0\\_specific-courses-and-Micro-Credentials\\_Final-Version.pdf](https://lcamp.eu/wp-content/uploads/sites/53/2025/05/LCAMP-Reporting_D5.3_Database-of-I4.0_specific-courses-and-Micro-Credentials_Final-Version.pdf) targeted at Industry 4.0 skills. These micro-credentials are short, focused training modules – “nano-credentials” in LCAMP's terminology –



each certifying mastery of a specific competency or cluster of skills. For example, instead of a long curriculum in automation, a nano-credential might cover programming a collaborative robot arm or implementing a predictive maintenance algorithm. WP5 designed a harmonized structure for all such credentials, ensuring each includes standardized metadata: a descriptive title, clearly defined learning outcomes, workload/hours, EQF level, assessment method, and linkage to ESCO skills and occupation profiles. This structure was deliberately aligned with the European micro-credentials framework set out in the Council Recommendation on micro-credentials (European Commission, 2022). By adhering to the common European standards for quality and transparency, LCAMP's micro-credentials are portable and recognizable across institutions and borders. In practice, any LCAMP nano-credential entry can be easily converted into a Europass Digital Credential (EDC; European Commission, n.d.) or an open badge, since all the mandatory metadata (issuer, learning outcomes, EQF level, etc.) are in place. This approach is fully in line with the European goal of making micro-credentials “flexible, targeted learning offers” that can be accumulated and transferred by learners throughout their careers. The rapid development of micro-credentials across Europe is driven by demand for more flexible, learner-centred education and training, especially to serve new kinds of learners and mid-career upskiller. By cataloguing dozens of such nano-credentials (over 230 were assembled in the LCAMP database.). WP5 is contributing to a new ecosystem of certified micro-learning that allows modular upskilling. Each nano-credential is a “building block” focusing on one assessed skill or competency bundle. These can be combined or “stacked” into larger qualifications – reflecting the principle that micro-credentials should be stackable toward full degrees or diplomas over time. For instance, multiple LCAMP nano-credentials in robotics and AI could eventually aggregate into an advanced certificate in smart manufacturing. This stackability is essential for creating learner-centric pathways that remain flexible: learners can progress step-by-step, earning small credentials that later count toward a bigger goal, rather than committing to a long program upfront.

### **Data-driven curriculum alignment with job profiles**

A unique strength of WP5 is how it closes the loop between industry skill needs and training curricula using data. Traditional curricula often lag behind industry changes, but LCAMP's approach is to continuously align its training offer with real-time skills intelligence. The project's Skills & Job Observatory (WP3) analyzes trends in advanced manufacturing – e.g. rising demand for industrial cybersecurity, AI-driven quality control, sustainable materials expertise – and feeds this intelligence into WP5. The micro-credentials in the catalogue were therefore not just chosen arbitrarily; they were selected and designed based on identified skill gaps and “future skills” forecasts. Each credential was tagged with ESCO skills and linked to relevant occupations to ensure that it teaches competencies that employers value. Moreover, WP5 team members conducted curriculum calibration workshops, reviewing how learning outcomes were written and tagged, to maximize alignment with European frameworks. For example, partners were coached to use consistent action verbs (Bloom's taxonomy) for learning outcomes and to accurately map those outcomes to ESCO skill descriptors. This meticulous tagging enables the platform to do smart matching: when a user looks at a job profile, the system can find which micro-credential's outcomes cover the needed skills. It mirrors broader European efforts where ESCO serves as a bridge between education and the labor market, by providing a common skills language to connect training to occupations. A recent study of digital VET tools found that using ESCO to map skills to job profiles allows AI-driven systems to generate tailored career and training recommendations for learners. LCAMP's platform embodies this principle – effectively operationalizing “skills-based matching.” When an advanced manufacturing company needs a certain competency (say, PLC programming or energy-efficient machining), the system can



identify which courses impart those skills, or conversely, given a person's skill set, it can suggest what upskilling is needed for various roles. This data-driven alignment ensures the curriculum remains agile: as new skill demands emerge (e.g. for cobot maintenance or battery recycling techniques), the system can highlight gaps and prompt the development or sourcing of new micro-credentials. In doing so, WP5 supports a continuous curriculum innovation cycle tightly coupled with industry needs – a hallmark of Vocational Excellence in the CoVE model.

## 2.3. INTEGRATED LEARNING PATHWAY SKILLS INTELLIGENCE IN ACTION

The capstone of WP5 is the Integrated Learning Pathways Tool (Deliverable 5.4) – a digital platform that brings together the profiling, skills intelligence, and micro-credential catalogue to deliver personalized upskilling pathways for learners. This tool is essentially the practical realization of the learner-centric ecosystem: it helps an individual navigate from their current skill set to a desired future job role through a sequence of targeted learning steps. According to the WP5 methodology, the Pathways Tool functions as follows:

The user (learner) begins by completing a skills self-assessment on the platform, rating their proficiency in various advanced manufacturing competences (technical, digital, green, etc.). The tool may also allow importing existing qualifications or even parsing a CV to auto-detect skills.

The user can then select or be matched to a job profile of interest from the database (for example, “Additive Manufacturing Specialist” or “Industrial Data Analyst”). The tool, using its job profile database (approximately 700 profiles), identifies the target role's required competences.

Through an automated gap analysis, the platform compares the user's skill profile to the target profile, pinpointing which required skills are already mastered and which are lacking (skill gaps). For each gap, the system quantifies the level difference (e.g. needs level 5 in CNC programming, but user is at level 3) and possibly links it to the EQF level context to indicate the complexity of learning needed.

The tool then queries the micro-credential and course catalogue to find learning opportunities that teach the missing skills. Thanks to the ESCO-based tagging, this matching can be very precise: for each required skill or competency cluster, the system finds one or more micro-credentials that cover that outcome. The result is a suggested learning pathway – essentially a sequence of recommended micro-credentials (or courses) to take, which collectively would fill the identified gaps. This pathway is modular and personalized: for example, it might recommend an introductory nano-credential on robotics safety (EQF 4) followed by an advanced credential on robot programming (EQF 5) to reach the needed proficiency. The recommendations take into account not just technical skills but also transversal skills; for instance, if the job profile values “problem-solving” or “teamwork”, the pathway might include modules (or experiential learning) to develop those, aligned with frameworks like EntreComp or LifeComp.

The user can then follow the pathway, enrolling in the suggested micro-credential courses (many of which may be offered online by LCAMP partners or through the platform's links). As they complete each and earn a credential, those achievements can be added to their profile (potentially as digital credentials in the Europass wallet). The platform could re-evaluate the profile after each step, updating the remaining gap – in this way, the pathway can dynamically adjust if the user acquires new skills elsewhere or their career goal changes.

Underlying this process is a tight integration of skills intelligence tools. WP5's pathway tool is not just a static course recommender; it includes components like a “Skill Finder” and “Job Call



Builder”. The Skill Finder helps match people to training or jobs by skill data, effectively bridging between “employer needs and educational offerings”. The Job Call Builder, on the other hand, is a feature that helps companies craft job vacancy postings with clear competency requirements. By using the same competency taxonomy (ESCO) across these tools, LCAMP creates a unified ecosystem: employers articulate what they need in a common skills language, individuals assess themselves in that language, and training offerings are tagged accordingly. This makes the learning pathways tool a two-way street – it can guide learners to jobs but also inform companies and VET providers about skill supply and demand. Indeed, one can envision that as the tool aggregates data (anonymously) on common skill gaps, it provides feedback to VET curricula and policy makers on where further investment in training is needed (supporting the EU Skills Agenda’s call for better skills intelligence).

From a European perspective, Deliverable 5.4 exemplifies how digital technology can facilitate lifelong learning. It operationalizes several policy frameworks: It uses the European Qualifications Framework (EQF) to map skill levels, ensuring that learning pathways can reference comparable levels across countries. It leverages ESCO to connect education and occupation data, echoing how ESCO “serves as a dictionary” for skills and jobs across Europe. It implements the European Learning Model (ELM) and Europass Digital Credentials (EDC) standards so that any credential issued via the platform is verifiable and shareable across the EU. For example, when a learner completes a nano-credential, the system could issue them a signed digital certificate embedded with machine-readable metadata (learning outcomes, EQF level, etc.) – this means the credential can be automatically recognized or even parsed by employers’ HR systems or added to the learner’s Europass profile. By integrating these elements, the LCAMP pathways tool aligns with the vision of an integrated European lifelong learning space. The European Commission explicitly encourages using and linking such tools: the 2022 Council Recommendation on micro-credentials urges Member States to empower individuals to “forge personalised learning and career pathways” and to adapt existing EU tools (like Europass, EQF, ESCO) to support micro-credentials. LCAMP WP5 is essentially a on-the-ground realization of these recommendations – providing a concrete model of how personalized, skills-based learning pathways can be delivered in practice.

#### Human-Centric and Flexible Transitions through LCAMP Nano-Credentials

A core theme throughout WP5 is human centrality, which mirrors the broader shift to Industry 5.0. Rather than expecting workers to conform to rigid training programs or be displaced by technology, the approach is to give learners agency and flexibility in navigating their careers. The learner-centric ecosystem built by LCAMP supports “high responsiveness to industry skill needs” while maintaining “greater flexibility for learners”, which are cited as key advantages of micro-credentials in vocational education. For example, a technician in an SME can, through the pathways tool, discover a short course that upgrades her skill in operating a new CNC machine, take it over a few weeks, earn a micro-credential, and immediately apply it at work – all without leaving her job for a full-time program. This kind of just-in-time upskilling is critical for SMEs and adult learners. SMEs often face acute constraints of time and budget for training, and employees cannot be away for long periods. Nano-credentials offer bite-sized, learning that can be slotted into work schedules, thereby lowering barriers for SME employees to gain new skills. Moreover, because each credential is competency-based and assessed, employers gain confidence that the training yields concrete, verifiable skills, not just attendance certificates.

The modular nature of nano-credentials also facilitates transitions for adult learners who may be shifting careers or returning to education. Rather than enrolling in a multi-year qualification (which can be intimidating or impractical later in life), they can progressively build a portfolio of micro-credentials that showcase their skills. This aligns with the EU’s emphasis on lifelong learning and inclusivity – micro-credentials “offer a flexible, targeted way to help people develop



the skills they need... and reach a wider range of learners”, including those who might not access traditional programs. In WP5, by integrating micro-credentials into a coherent pathways system, LCAMP ensures that even though learning is modular, it is not fragmented. Each nano-credential is part of a larger “personalised learning pathway”, so the learner sees how it contributes to their broader career goals (for instance, obtaining several 5-ECTS nano-credentials in machine automation could eventually lead to a diploma). This nano-credentialing approach embodies a “learner-centric micro-degree” concept. A learner can gradually attain the equivalent of a higher VET qualification through accumulated micro-units, with the option to pause, resume, or change direction as needed. Such flexibility is particularly valuable for mid-career workers balancing family, jobs, and learning. It also supports just transitions in the economy – as some jobs are disrupted by automation or the green transition, workers can rapidly retrain via targeted micro-credentials for new emerging roles, rather than facing long unemployment or having to start education from scratch.

WP5’s work is strongly connected to European frameworks and initiatives that enable these human-centric, flexible transitions. The European Qualifications Framework (EQF) provides the common reference for levels, so a worker’s micro-credential at EQF 5 is understood similarly whether earned in Spain or Germany. The Europass Digital Credentials (EDC) infrastructure, built on the European Learning Model (ELM), allows those credentials to be digitally issued and verified across Europe. By tagging every nano-credential with the relevant ESCO skills and occupation codes, LCAMP ensures that what the learner achieved is transparent to any employer or institution – a critical aspect for recognition and trust in micro-credentials. This trust-building is exactly what the Council Recommendation (2022) stressed: without common standards for transparency and quality, micro-credentials “cannot reach their full potential”. LCAMP addresses this by rigorously applying those standards, thereby fostering recognition. In addition, LCAMP’s alignment with EU tools exemplifies how EU-level support structures (like Erasmus+ funding for CoVEs, and the Europass platform) can catalyze innovation in VET. The project also feeds into the goals of the Pact for Skills (which prioritizes upskilling in industrial ecosystems) and the European Skills Agenda action to “[support] the uptake of micro-credentials” and lifelong learning.

In conclusion, Work Package 5 of the LCAMP project demonstrates a comprehensive, data-informed approach to creating a learner-centric training ecosystem in the advanced manufacturing sector. By integrating skills profiling, micro-credentialing, and intelligent pathway planning, WP5 provides a model of how vocational training can become more agile, modular, and personalized. This model directly supports human-centric and flexible transitions for Europe’s workforce – enabling individuals to continuously adapt their skills in line with Industry 4.0/5.0 developments, and empowering SMEs to remain competitive through upskilling. The use of European frameworks (EQF, ESCO, ELM) and tools (Europass EDC) ensures that these innovations do not happen in isolation but rather reinforce a Europe-wide ecosystem of lifelong learning and skills recognition. Ultimately, LCAMP WP5’s learner-centric innovations contribute to the broader vision of a resilient, innovation-ready European manufacturing industry – one where people and their skills are at the heart of the digital and green transition.

## 2.4. OVERVIEW AND OBJECTIVES

The Integrated Learning Pathways Tool is a web-based platform that offers users a guided process for assessing their current skills, identifying gaps and planning personalised training pathways. It combines career self-assessment, job matching and the recording of learning opportunities in one integrated system. Through a detailed assessment of a user’s career goals, experience and skills, the tool enables individuals to actively plan their own career path and find



targeted training courses to achieve their desired AM job profiles. Ultimately, the tool aims to link the results of the skills assessment to relevant job profiles and recommended courses/micro-certificates, empowering learners and workers to achieve their career goals in the evolving Industry 4.0/5.0 landscape.

The tool is aimed at three main target groups, each with specific objectives:

### **Learners and employees:**

Individuals (including students, employees and job seekers) use the tool for self-assessment and career planning. The platform assesses their current skills and competencies, matches them with suitable AM job profiles, identifies skills gaps and then suggests personalised learning paths (modular courses or micro-certificates) to fill those gaps. Users also gain insight into possible career paths and future roles in advanced manufacturing. This supports both the upskilling of existing employees and the retraining of career changers, as demonstrated by LCAMP's use case for adult learners who use the Skills Profiler to explore new paths.

### **HR professionals:**

For human resources managers and developers in industry, the tool offers a comprehensive database of AM job profiles and skills assessment functions to evaluate the skills of their employees. HR users can identify skills gaps in the workforce in relation to industry requirements and receive guidance on designing targeted training programmes. The tool thus supports companies in strategic talent management, succession planning and aligning training investments with the skill requirements of Industry 4.0. It also offers resources for anticipating future skill requirements (through embedded observation data on AM trends).

Vocational training/higher education instructors and trainers: Vocational training and higher education institutions and instructors use the tool to align curricula and training programmes with industry requirements. The tool provides insights into in-demand skills and job role requirements and helps instructors tailor their programmes accordingly. It supports the design of new micro-certificates and courses by highlighting gaps between current training and industry competency requirements. Trainers and career advisors can also use the platform as a counselling tool to help learners select modules or qualifications that will advance their career paths in advanced manufacturing.

Objectives of the tool: In line with the specific objectives of the LCAMP project (WP5), this tool serves as an integrative component that brings together all the data and services required for learner-centred training in AM. Key objectives include:

Competence profiling and job matching: Provision of a sophisticated competence assessment toolkit (incorporating LCAMP Deliverable D5.2) that profiles an individual's competences against a framework of Industry 4.0 competences and algorithmically matches users with relevant AM job profiles based on their current competences. This directly implements LCAMP's goal of improving skills profiling and matching with industry requirements.

Gap analysis and personalised learning paths: Automatic analysis of the gaps between the user's current skills and the skills required for the target job profiles. Based on the identified gaps, personalised, modular learning paths are created, consisting of recommended courses and micro-credentials (from the curated database developed in D5.3) to improve the user's skills. The learning paths are modular and flexible, allowing users to complete short training units (nano-credentials) that can be combined into larger qualifications, reflecting the EU's vision for micro-credentials in the field of lifelong learning.



Integration and recognition of micro-credentials: Integration of a database with Industry 4.0-specific courses and micro-credentials (LCAMP D5.3) into the tool to ensure that the recommended learning opportunities are up to date and targeted. The tool acts as a 'clearing house' for micro-credentials and follows European standards (e.g. the European approach to micro-credentials) to ensure that all proposed credentials are recognised and transferable. Each micro-certificate entry in the system contains standardised metadata (learning outcomes, EQF level, workload, etc.) in accordance with the formats of the European Learning Model (ELM) and the European Digital Credentials (EDC) Infrastructure. This guarantees the interoperability and recognition of acquired skills and is in line with LCAMP's SO14 objective of basing training offerings on EU standards for micro-qualifications.

#### **Visualisation of career paths:**

Enable users to visualise potential career paths in advanced manufacturing. Starting from any job profile, the tool highlights related positions (e.g. entry-level vs. advanced positions in the same career path) and shows how acquiring new skills can lead to promotion opportunities or specialisations. This helps workers and students understand different future possibilities and motivates lifelong learning. Emphasising career paths makes the concept of 'lifelong learning' tangible and shows a roadmap from the current position to new roles in Industry 5.0.

#### **Integrated platform features:**

Ensure that the tool is fully integrated into the broader LCAMP digital platform (WP8) and supports a seamless user experience. Key features include a multilingual user interface (available in at least 6 languages: EN, ES, FR, IT, TR, SL, to facilitate accessibility in all partner regions), a user management system with role-based access (so that different user types see the appropriate dashboards), and data exchange functions (import/export of profile data, interoperability via APIs) for connection to other systems. The tool also logs usage analytics for continuous improvement and monitoring based on KPIs.

## **2.5. HOW D5.4 BUILDS UPON D5.2 AND D5.3**

The development of the integrated learning path tool builds on several previous results and foundations of LCAMP:

The Industry 4.0 competence framework developed in earlier project phases (Deliverable D5.1 & D5.2) provides the taxonomy of competence and qualification levels that underlies the competence assessment component. This ensures a uniform definition and measurement of competences.

The skills assessment toolkit (D5.2) serves as the core element for creating user competence profiles. The reflective self-assessment methodology and software modules from D5.2 are integrated here as the first step of the Pathways tool. As mentioned in D5.2, this toolkit 'laid the foundation for the further development of LCAMP's innovative learning approach' and enabled user-friendly assessment for workers and learners in additive manufacturing. By embedding the functions of D5.2, the Pathways tool can use a proven mechanism to capture a user's competence profile across professional and transversal skills domains.



The database of I4.0-specific courses and micro-certificates (D5.3) is fully linked to the tool. This database contains a curated catalogue of training opportunities (over 230 “nano-certificates” compiled from partner offerings and also MOOCs), which the tool queries to recommend learning modules relevant to each user's skills gaps. Importantly, D5.3 has established common descriptors and metadata for each course (title, learning outcomes, EQF level, etc.), using the European Digital Credential metadata for interoperability. By integrating this database, the Pathways tool supports the recognition of learning outcomes across institutions and borders and complies with Europass and ESCO standards for the description of qualifications.

An initial schema for job profiles was jointly designed by the LCAMP partners (led by KIC, DHBW and TKNIKA) to standardise the description of job roles in advanced manufacturing. This schema, which has been refined through feedback from partners, forms the structural basis for the job profile database within the tool. It ensures that each profile contains consistent fields (job title, description, required skills, etc.) and mappings to frameworks such as ESCO and EQF.

By combining these building blocks (competence framework, self-assessment toolkit, micro-certificate database and standardised occupational profiles), the Integrated Learning Pathways Tool provides a unified platform where users can identify their competence gaps and immediately find targeted learning resources to fill those gaps. This directly supports LCAMP's vision of a learner-centred platform for advanced manufacturing that promotes excellence through continuous learning.

## 2.6. CONTRIBUTION TO PROJECT INDICATORS AND POLICY PRIORITIES

Deliverable D5.4 contributes significantly to the achievement of the LCAMP project indicators and to key European policy priorities related to skills intelligence, lifelong learning, and workforce development in Advanced Manufacturing.

A central contribution of this deliverable concerns the identification, structuring, and integration of job profiles relevant to Industry 4.0 and 5.0. The project initially targeted the collection of approximately 700 job profiles across all participating partners, including VET providers, associated partners, and industry partners. Following implementation, a total of approximately 700 validated job profiles were completed and integrated into the LCAMP ecosystem. This adjustment is linked to the justified non-contribution of Canadian partners, whose qualification and occupational frameworks differ substantially from European reference systems, limiting the comparability of job profile data with EQF- and ESCO-based structures.

Despite this adjustment, the resulting dataset represents a broad and representative coverage of Advanced Manufacturing occupations across multiple European countries and qualification levels. The job profiles provide a robust foundation for aligning labour market needs with education and training provision and play a key role in enabling skills gap analysis, job matching, and the generation of personalised learning pathways within the Integrated Learning Pathways Tool.

From the perspective of project indicators, the job profiles directly support KPIs related to labour market relevance, industry engagement, and data-driven training design. The profiles were



developed and validated in close collaboration with industry partners, ensuring that they reflect current and emerging skill requirements driven by digital and green transitions in manufacturing.

In terms of policy alignment, Deliverable D5.4 contributes directly to European priorities such as the European Skills Agenda, the Pact for Skills, and the Council Recommendation on micro-credentials (2022). By structuring job profiles in alignment with European frameworks such as EQF and ESCO, the deliverable supports interoperability, transparency, and comparability of skills and qualifications across borders. This alignment strengthens the role of the LCAMP platform as a tool for promoting lifelong learning, employability, and workforce resilience within the European Advanced Manufacturing ecosystem.

## 3. OVERALL APPROACH

### 3.1. SUMMARY OF METHODOLOGY

The development methodology for the tool was comprehensive and iterative, ensuring both technical robustness and content validity. It involved parallel workflows: (a) collection and curation of occupational profile data, (b) platform development and integration, and (c) testing and quality assurance, all of which were subject to a strict quality management plan. The approach was guided by several key principles: standardisation of data, alignment with European frameworks (EQF, ESCO), validation by industry, multilingual inclusivity, and continuous feedback from stakeholders. The following subsections describe the data collection and tool development processes in detail.

### 3.2. PROJECT KPIS

Deliverable D5.4 contributes directly to several Key Performance Indicators (KPIs) of the LCAMP project, particularly those related to the collection and structuring of job profiles, the alignment between labour market needs and training provision, and the development of learner-centred pathways in Advanced Manufacturing.

A key KPI addressed by this deliverable concerns the number of job profiles collected and integrated into the LCAMP ecosystem. The initial project objective foresaw the identification and structuring of approximately 800 job profiles across participating countries, involving VET providers, associated partners, and industry partners. Following implementation, a total of approximately 700 validated job profiles were completed and integrated into the project databases.

This adjustment from the initial target is linked to the justified non-contribution of Canadian partners to the job profile dataset. While Canadian organisations formally participated in the project, differences between the Canadian qualification and occupational frameworks and the European reference systems (notably EQF and ESCO) limited the feasibility of producing job profiles that were methodologically comparable with European data. The decision not to include Canadian job profiles ensured consistency, comparability, and alignment with European standards across the dataset.



Despite this adjustment, the final number of job profiles represents a substantial and representative dataset covering a wide range of Advanced Manufacturing occupations and qualification levels. These job profiles form a critical input for skills gap analysis, job matching, and the generation of personalised learning pathways within the Integrated Learning Pathways Tool.

In addition, D5.4 contributes to KPIs related to industry engagement and validation, as the job profiles were developed and reviewed in close collaboration with industry partners across eight countries. This collaboration ensures that the profiles reflect current and emerging Industry 4.0 and 5.0 skill requirements.

Finally, the deliverable supports KPIs related to European coverage, interoperability, and sustainability, as all job profiles are structured using harmonised templates and aligned with European frameworks such as EQF and ESCO. This alignment enables their effective use within the LCAMP platform and supports long-term reuse by VET providers, companies, and other Centres of Vocational Excellence.

## **4. CONCEPT AND OBJECTIVES OF THE INTEGRATED LEARNING PATHWAYS TOOL**

### **4.1. THE LEARNING PATHWAYS TOOL**

Within the LCAMP project (Learner Centric Advanced Manufacturing Platform), the Integrated Learning Pathways Tool is envisioned as a cornerstone solution addressing the urgent need for adaptable, modular upskilling in the Advanced Manufacturing sector. In essence, this tool provides guided pathways for lifelong learning: it evaluates an individual's career goals, prior experience, and existing competencies to chart a personalized development plan. By acting as a bridge between defined job profiles, skills assessments, and available learning opportunities, the tool guides users through tailored upskilling journeys. The overarching goal is to empower workers and learners to actively plot their career development in the face of rapid Industry 4.0/5.0 transformations. This means helping individuals identify skill gaps relative to emerging job requirements and then recommending targeted training (e.g. courses or micro-credentials) to fill those gaps. Ultimately, the Integrated Learning Pathways Tool supports the LCAMP mission of making lifelong learning a practical reality in Advanced Manufacturing, ensuring that training is modular, flexible, and learner-centric rather than one-size-fits-all.

Crucially, the development of this tool aligns with several specific objectives of the LCAMP initiative. It directly contributes to building a skills assessment toolkit for users (LCAMP objective SO12) and creating a rich database of advanced manufacturing training courses and micro-credentials (SO13). In addition, it underpins the establishment of a "clearing house" for micro-credentials and trainings that adheres to European standards (SO14) and supports the development of new Industry 4.0-focused micro-credentials (SO15). By fulfilling these goals, the



tool integrates multiple project outputs into one coherent system, thus serving as a cornerstone of the LCAMP platform's offering for learner-centric upskilling.

### **Alignment with LCAMP Objectives and Advanced Manufacturing Upskilling**

The Integrated Learning Pathways Tool is designed in harmony with LCAMP's broader objectives of fostering resilient, innovation-driven vocational training in Advanced Manufacturing. LCAMP, as a network of Centres of Vocational Excellence (CoVEs) in this sector, emphasizes modular lifelong learning for both students and workers. The tool addresses this by providing flexible learning pathways that can quickly adapt to industry changes. Notably, it emerges from the recognition that Industry 4.0 and 5.0 trends demand continuous re-skilling; traditional linear education models often fail to keep pace. This tool's modular approach – breaking learning into smaller certified units (courses, micro-credentials) – directly tackles that challenge. It enables a culture of continuous upskilling where learners can incrementally acquire new skills as technology evolves, rather than undertaking only infrequent, large qualifications. This approach aligns with the European Skills Agenda, which calls for tools to support lifelong learning pathways and specifically highlights micro-credentials as a key initiative. By integrating micro-credentials and personalized learning plans, the tool reflects the Agenda's push for “more and better skills” and the need to widen learning opportunities for all adults.

Furthermore, the tool is learner-centric by design. It incorporates principles from educational research on self-directed learning and reflective practice (as noted in LCAMP Deliverable D5.2) to engage users in managing their own skill development. The emphasis is on empowering individuals (be they students, employees, or job-seekers) to take charge of their career trajectories. At the same time, the tool serves institutional goals: it helps VET/HVET providers align curricula with industry needs and assists companies (HR departments) in planning workforce development. In this way, the Integrated Learning Pathways Tool supports LCAMP's multi-stakeholder approach – connecting learners, education providers, and employers – to ensure the advanced manufacturing workforce can continuously update its competencies. By guiding users through personalized upskilling pathways, the tool contributes to LCAMP's intended outcomes such as identifying high-demand skills gaps (KPI I34) and developing new micro-credentials for those skills (KPI I35). All of these align with making the advanced manufacturing sector's workforce more agile and prepared for digital transformation.

### **Structure and Key Functionalities of the Tool**

In Deliverable D5.4, the Integrated Learning Pathways Tool is described in terms of several key functionalities that together create a comprehensive user experience:

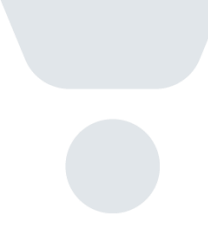
#### **Skills Self-Assessment:**

At the core is a skills assessment toolkit, which allows users to profile their current competencies. This self-assessment is sophisticated, evaluating the user's knowledge, skills, and even certain personal traits against industry-defined competency frameworks. The idea is to give learners a clear picture of what they already know and can do, in a structured way. This component builds upon the earlier LCAMP Skills Assessment Toolkit (Deliverable D5.2) and research-backed methods for self-evaluation. By reflecting on their own skills, users become active participants in identifying their learning needs.

#### **Job Profile Matching:**

The tool includes a database of job profiles in Advanced Manufacturing – essentially detailed descriptions of roles (e.g. CNC Operator, Robotics Technician, Industrial Data Analyst). After assessing one's skills, the system can match the user to relevant job profiles that suit their





current skill set. This matching goes beyond simple keyword matching; it uses the competency data to find roles that the individual is already partially qualified for. The job profiles themselves are standardized and enriched with industry input, each listing the competencies and qualifications typically required. By seeing which real-world roles align with their profile, users gain insight into possible career opportunities or next steps.

### **Skill Gap Analysis:**

For any target job profile, the tool performs a gap analysis. It compares the user's current competencies (from the self-assessment) with the competencies required by that job. The result is a personalized report of "skill gaps" – specific skills or knowledge areas the user lacks or needs to strengthen. For example, a user may discover they need more proficiency in industrial IoT or a certification in a certain CAD software to be fully qualified for a desired role. This gap analysis is critical as it informs the subsequent recommendations; it essentially pinpoints what the learner needs to learn next in order to achieve their goal.

### **Personalized Learning Pathway Recommendations:**

Perhaps the most innovative feature is the automatic generation of custom learning pathways to close the identified skill gaps. The tool suggests educational resources – notably nano-credentials and micro-credentials (short, competency-focused courses or certifications) – that the user can pursue to acquire the missing skills. In practice, this means the system queries a catalog of approved training courses and micro-credential offerings (developed in Deliverable D5.3) for those that teach the required competencies. The output is a sequenced pathway: a clear roadmap of courses, credentials, or modules the learner could take, often in modular form, to progress from their current state to the target competence level. These pathways are personalized: for instance, an early-career technician might be recommended an introductory "nano-course" in robotics safety, whereas an experienced engineer targeting a specialized role might be pointed to an advanced micro-credential in data analytics for manufacturing. By stitching together several small learning units, the tool constructs an individualized upskilling journey for each user.

### **Multilingual Support:**

Given that LCAMP is a pan-European project with partners in multiple countries, the Integrated Learning Pathways Tool supports multiple languages (at least the six project languages: English, Spanish, French, Italian, Turkish, Slovenian). The interface and content (job profiles, skill descriptions, etc.) are available in these languages, lowering barriers for users across Europe. This is crucial for accessibility and aligns with the project's inclusion goals. A multilingual approach also ties into quality, as content was developed with translation and consistency in mind (a multilingual strategy is described in D5.4's methodology to ensure terms and definitions remain consistent across languages).

### **Data Export and Interoperability:**

The tool is built as part of the LCAMP digital platform with an emphasis on data portability and openness. Users and administrators have the ability to export data in multiple standard formats, ensuring that information generated within the system can be utilised across different contexts and platforms.

### **Architecture and Integration with the LCAMP Platform**

The Integrated Learning Pathways Tool is not a standalone application; it is conceived as an integral module of the broader LCAMP online platform (developed under WP8). Its architecture builds upon and interfaces with several other LCAMP components and work packages:



### **Job Profile Database:**

A core element underpinning the tool is the database of Advanced Manufacturing job profiles. In the project's methodology, over 700 job profiles are being collected across the partner regions, each following a standardized template. This template includes details like the role description, required skills, required qualification level (mapped to EQF), and relevant industry sector. The job profiles are structured in alignment with European skills taxonomies (ESCO/ISCO codes) and cover a range of qualification levels (initially focusing on EQF levels 3–6). The architecture ensures that this job profile database is accessible to the pathway tool: when the user's skills are assessed, the system queries this database to find matching roles and to retrieve the skill requirements of target roles for gap analysis. The quality assurance for these data (multi-stage reviews by TKNIKA, DHBW, industry validation, etc. as detailed in D5.4) ensures that recommendations are based on trusted, accurate job definitions.

### **Skills Assessment Toolkit (D5.2):**

The self-assessment functionality of the tool leverages the Skills Assessment Toolkit developed in Deliverable D5.2. That toolkit provides the mechanisms (likely questionnaires, tests, or reflection prompts) for evaluating a user's proficiency in various Industry 4.0 competencies. By integrating D5.2's toolkit, the pathway tool inherits a research-informed approach to self-assessment, including the competency framework defined by LCAMP's earlier work (the Industry 4.0 Skills Framework from D5.1). The architecture thus connects the front-end user interface (where a user rates their skills or answers questions) with the back-end competency framework and assessment logic from D5.2. This integration was a planned milestone – for example, LCAMP scheduled the platform to have “integration of D5.2 skills assessment tool and D5.3 micro-credentials database” by mid-2025. Technically, this means common data standards for representing skills and proficiency levels are used, so that the assessment results can feed directly into gap analysis.

### **Courses and Micro-Credentials Database (D5.3):**

Deliverable D5.3 developed a database of Industry 4.0-specific courses and micro-credentials across Europe. The Integrated Learning Pathways Tool is designed to connect to this database to pull in learning opportunities for its recommendations. In practice, once skill gaps are identified, the tool can search the D5.3 course catalog for suitable training modules or micro-credential programs that teach those skills. Because D5.3 catalogued courses along with rich metadata (title, learning outcomes, EQF level, etc.), the tool can filter and match courses to the user's needs. The architecture integration point here is likely an API or direct database query: the pathway tool sends a query like “find all courses that cover Skill X at EQF level 5” to the micro-credentials database. The returned results populate the list of recommended learning pathway steps. Notably, D5.3's database was built as a “clearing house” of training opportunities, meaning it aggregates offerings from multiple providers and countries, standardized for easy comparison. This federated approach aligns with the tool's need to provide choices to the learner (e.g. multiple courses that could fill a skill gap, possibly in different languages or formats).

### **LCAMP Skills Intelligence Observatory (WP3):**

The tool's design also considers integration with WP3, the Skills and Jobs Observatory. The Observatory suite in LCAMP (WP3) collects and disseminates data on emerging skill needs, job market trends, and technology forecasts in advanced manufacturing. While WP3 operates at a higher level (producing reports and analysis), its insights feed into the pathway tool to ensure recommendations remain relevant. For example, if the Observatory identifies a new in-demand skill (say, knowledge of a specific AI tool in manufacturing), that skill can be added to the competency framework and new micro-credential offerings can be developed or included. The



integration is thus conceptual and data-driven: the tool's database of skills and job profiles is regularly updated with intelligence from WP3, so that users are assessing themselves against up-to-date industry requirements. By informing the job profile definitions and highlighting "skills in high demand", the Observatory helps the tool focus on the right competencies. In turn, the pathway tool provides a practical channel to disseminate Observatory findings to end-users – for instance, learners will directly see new skills and roles emerging, and training providers (through the tool) see where to invest in new courses. This virtuous cycle was envisioned in the project proposal: "input received through the industry 4.0 network and the Observatory will improve understanding of skill demand and enable people to make better career choices, find quality job descriptions with required skills, and improve their life chances". Thus, the pathway tool operationalizes the Observatory's labor market data by integrating it into personal guidance for learners.

### **Overall Platform Integration:**

The Integrated Learning Pathways Tool operates as part of the broader LCAMP ecosystem while maintaining distinct access management aligned with different user populations and use cases.

The LCAMP platform employs a dual-access structure. The Skill Profiling & Recommendation Engine is designed as an open-access tool available to any learner seeking to assess their skills, identify career opportunities, and discover relevant learning pathways. Users create accounts specifically for the WP5 tools, enabling broad public access without requiring institutional affiliation or alliance membership. In contrast, other LCAMP platform components, including the Open Innovation Community (WP4) and additional institutional resources (WP6), are reserved for LCAMP Alliance members. These tools require separate authentication and are accessible only to users affiliated with partner organizations and institutions within the alliance. This separation reflects the different purposes and audiences of each platform component: WP5 serves individual learners in an open, inclusive manner, while WP4 and WP6 facilitate collaboration and resource-sharing among institutional partners.

In summary, the architecture of the Integrated Learning Pathways Tool is inherently modular and integrative. It builds existing modules (assessment toolkit, course database) and feeds into a unified platform. This approach not only avoids duplicating efforts but also ensures that improvements in one component (e.g. expanding the course catalog, refining the skills framework) directly benefit the pathway guidance. The outcome is a robust system where data flows between job profiles, user profiles, and learning opportunities to generate individualized learning pathways. By connecting WP3, D5.2, D5.3, and other data sources, the tool exemplifies a holistic platform for skills intelligence and development in Advanced Manufacturing.

### **Alignment with European Frameworks (EQF, ESCO, ELM, EDC) for Interoperability**

A key strength of the Integrated Learning Pathways Tool is its deliberate alignment with European frameworks for skills and qualifications, ensuring interoperability, recognition, and transferability of the tool's outcomes across the EU. The design acknowledges that for the tool to be truly effective and scalable, it must speak the "common language" of European education and labor market systems:

#### **European Qualifications Framework (EQF):**

The EQF provides a standardized reference for the level of a learner's knowledge, skills, and competence on an 8-level scale (from basic to doctoral level). The LCAMP tool uses EQF levels as a fundamental metric when handling both job profiles and learning opportunities. All job profiles in the database indicate the typical EQF level of the role (e.g. a technician role might be EQF 4, an engineer EQF 6). Similarly, the recommended micro-credential courses are tagged



with the EQF level of learning outcomes they confer (D5.3 focused on courses at EQF 3–6, relevant to vocational and higher vocational training). By doing so, the tool can map pathways that involve progression across EQF levels. For instance, if a learner aspires to move from an EQF 4 role to an EQF 5 role, the tool will identify the additional learning (often at EQF 5 level) required to make that transition. The use of EQF ensures that the level of difficulty and complexity of skills is transparent and comparable Europe-wide. It also supports recognition: when a learner obtains a micro-credential recommended by the tool, the EQF label attached to it helps employers or institutions in other countries understand its level. In essence, EQF alignment makes the tool’s guidance portable and understandable across borders, facilitating learner mobility and career shifts around Europe.

### **ESCO (European Skills, Competences, Qualifications and Occupations):**

ESCO is the European Commission’s multilingual classification of skills and job profiles. LCAMP has closely aligned the data structures of the pathway tool with ESCO to ensure semantic interoperability. Each job profile in the tool is mapped to an appropriate ESCO occupation code, and the skills within that profile are referenced to ESCO skills definitions wherever possible. For example, if the tool lists “PLC programming” as a required skill, it will link that skill to the corresponding ESCO skill entry/URI, which provides a standardized definition. Using ESCO brings multiple benefits: (1) It ensures common terminology – a “CNC programming” skill means the same thing across different countries and contexts; (2) It enables linking with other systems that use ESCO (like national job portals or other EU tools) – the skills data can be exchanged without loss of meaning. Additionally, LCAMP maps each job profile to an ISCO-08 code (the international standard classification) for broader compatibility, but ESCO provides the richer and evolving taxonomy including green skills and digital skills. By embedding ESCO, the Integrated Learning Pathways Tool ensures that its content is future-proof and connected to European-wide labor market information. It also helps with updating content: as ESCO updates with new skills (e.g. new technical competences in Industry 5.0), those can be incorporated into the tool’s framework.

### **Europass European Learning Model (ELM):**

The tool’s design takes into account the European Learning Model, which is a semantic standard for describing learning opportunities, credentials, and qualifications in a structured way. In practical terms, when the LCAMP D5.3 database recorded courses and micro-credentials, the team documented each offering with the mandatory metadata fields defined by the Europass framework. These fields correspond to the elements recommended by the Council (e.g. title of credential, learning outcomes, workload, EQF level, awarding body, etc.). Adhering to ELM means that the micro-credentials recommended by the tool carry all the information needed for recognition and are described in a machine-readable, standardized format. For example, if a recommended micro-credential is “Introduction to Industrial Robotics (EQF 4, 5 ECTS, offered by XYZ Institute)”, all those pieces of information are structured according to ELM standards. The benefit is twofold: (1) Interoperability – other platforms or digital credential repositories (like the Europass portal) can ingest the information easily. In fact, the LCAMP platform could export a learner’s pathway or attained micro-credentials in an ELM-compliant XML or JSON, which could be uploaded to the learner’s Europass profile. (2) Consistency with EU policy – by using the European Learning Model schema, the tool directly implements European policy guidance on transparency of credentials. The ELM is built on open standards and intended for broad use, so LCAMP’s adoption of it exemplifies following best practices for modern lifelong learning tools.

### **European Digital Credentials (EDC) and Micro-Credential Standards:**

The LCAMP tool also embraces the concept of European Digital Credentials for Learning – essentially the EU’s approach to issuing verifiable, digitally signed certificates (through the



Europass Digital Credentials Infrastructure). While LCAMP itself may not issue credentials, it ensures that any micro-credential in its database could be issued as an EDC-compliant credential. Deliverable D5.3 explicitly states that the catalog of courses and micro-credentials was designed to leverage the European Digital Credentials metadata, aiming for “enhanced interoperability”. This means fields like learning outcome statements, notional workload (e.g. ECTS credits), type of assessment, and quality assurance are recorded for each credential, exactly as per the European Council Recommendation on micro-credentials (June 2022). By aligning with the Council Recommendation’s standard elements, the tool ensures that a micro-credential recommended (or eventually attained) via LCAMP will contain all necessary information for it to be recognized and trusted by other institutions or employers. For example, the Council Recommendation requires micro-credentials to include the awarding body and assessment type. LCAMP’s database captures those details, so if a learner completes a micro-credential and adds it to their CV, any evaluator can understand its value. In addition, should the learner choose to store their credentials in the Europass platform (Action 11 of the Skills Agenda, the information can flow seamlessly. The notion of portability is key here – a principle from the EU’s approach is that learners own their micro-credentials and can share them digitally across borders.

LCAMP supports this by making sure credentials are in formats that can be digitally transferred (the platform likely will allow exporting credentials to a digital wallet or PDF with verification links). The project’s commitment to EU standards is evident: “Since micro-credentials are a relatively new concept in VET... part of the work in D5.3 was ensuring alignment with emerging standards and frameworks. By following these standards, the Integrated Learning Pathways Tool not only helps users earn new credentials.

In summary, the tool’s alignment with EQF and ESCO guarantees that its content (skills, jobs, courses) is anchored in a widely understood reference framework, facilitating comparisons and integration with labor market tools. Its use of ELM and EDC standards ensures that the credentials and learning opportunities it deals with are described in a structured, interoperable manner, making the tool part of the larger European ecosystem for lifelong learning. This conscious design choice future-proofs the LCAMP platform: as Europe moves toward greater integration of credentialing (through initiatives like the Europass platform and the European Education Area goals for 2025), the Integrated Learning Pathways Tool will be compatible and complementary. Learners using the tool can trust that the advice they receive and the credentials they earn will be recognized, stackable, and shareable across institutional and national boundaries, a critical factor for lifelong learning in a modern, mobile workforce.

### **Primary Users and Use Cases of the Pathways Tool**

The Integrated Learning Pathways Tool is built to serve multiple user groups, each with distinct needs, within the Advanced Manufacturing skills ecosystem. LCAMP Deliverable D5.4 identifies three primary categories of end-users and outlines how each group will interact with the tool:

#### **Learners and Workers:**

This group includes individuals seeking to upskill or reskill – for example, current students in VET/HVET programs, young graduates entering the manufacturing sector, or existing workers looking to advance their careers. For learners, the tool functions as a personalized career navigator. Use case: A worker can perform a self-assessment to catalog their current skills, then see which advanced manufacturing job roles match their profile. Suppose a machinist finds that their skills closely match a “CNC Programmer” profile except for a gap in data analysis; the tool will highlight this gap and recommend specific micro-credential courses (perhaps a short course in “Statistical Process Control”) to address it. The learner can then follow the suggested learning pathway, eventually bridging the gap and becoming eligible for a promotion or new job. Learners



thus use the tool for career planning, getting a clear view of the competencies needed for their desired roles and a step-by-step plan to acquire those competencies. They also benefit from seeing potential career progression: the tool might show them that after becoming a CNC Programmer (EQF 4) and taking further credentials, they could aim for a CNC Automation Specialist (EQF 5) and later a Production Systems Analyst (EQF 6), giving long-term motivation. In short, for learners the tool provides self-assessment, job matching, and upskilling guidance in one place, making the often daunting task of lifelong learning more manageable and goal-oriented.

### **HR Professionals and Industry Employers:**

This group covers company HR departments, training managers in manufacturing firms (including SMEs), and other employer representatives focused on workforce development. For them, the tool serves as a skills management and planning resource. Use case: An HR manager at a manufacturing company can access the tool's job profile database to clarify the skills required for various roles within Industry 4.0. If the company is adopting new digital technologies, the HR manager might use the tool to identify what new roles or competencies are emerging (leveraging the curated profiles aligned with Industry 4.0 frameworks). They can then assess their current employees' skill profiles (with permission, employees could undergo self-assessment and share results) to see where the gaps lie. The tool's gap analysis feature can be applied at a team or company level – e.g., discovering that the workforce lacks expertise in additive manufacturing or cybersecurity. Based on this, the HR manager can plan targeted upskilling programs: the tool will suggest relevant micro-credentials or courses that the employees could take, and the HR manager might coordinate with training providers to enroll staff in those. The benefit here is that the tool provides evidence-based guidance for training decisions, rather than HR relying on guesswork or generic training packages. Additionally, when recruiting, HR professionals can use the tool to craft job descriptions with precise skill requirements (since each job profile comes with a list of needed skills mapped to a framework). This ensures a common language between what the company seeks and what training providers teach. Ultimately, the tool helps industry ensure their workforce development aligns with the latest industry skill standards and helps in identifying future skill needs so that companies can proactively train their staff.

### **Supporting Transitions with Stackable Credentials and Agile Pathways:**

A defining feature of the Integrated Learning Pathways Tool is how it facilitates agile learning pathways that can adapt to the fast-changing skill requirements of the advanced manufacturing sector. Central to this is the concept of stackable credentials – the idea that learners can accumulate small units of learning (micro-credentials, nano-credentials, certificates) over time, which “stack up” to broader qualifications or expertise profiles. The tool actively operationalizes this concept in several ways.

### **Support for Lifelong Learning Culture:**

By enabling stackable, agile pathways, the tool cultivates a mindset of continuous development. Rather than viewing education as one-off phases (school, then career), users are encouraged to see it as an ongoing process – an idea very much at the heart of EU policies like the European Skills Agenda (2020). Action 10 of the Skills Agenda specifically called for a European approach to micro-credentials to help widen learning opportunities for everyone, and the LCAMP tool is a concrete implementation of that: it widens opportunities by breaking them into accessible chunks and providing clear roadmaps. The tool's success will be reflected in how many learners it guides through these stackable routes. LCAMP even set a KPI (I30: 1000 skills profiles performed) to track user uptake, and KPIs around micro-credentials developed and user satisfaction – implicitly measuring how well the approach of modular learning is received.



In conclusion, the Integrated Learning Pathways Tool actively supports transitions across EQF levels and agile, stackable learning pathways by making the path to upskill transparent and modular. It embodies the principle that small, cumulative learning steps can lead to significant career advancement. This approach benefits learners (who get flexibility and control), employers (who see quicker upskilling and skill adaptability), and the education system (which can be more responsive and personalized). By situating these pathways within European recognition frameworks, the tool ensures that no learning effort is wasted – each nano-credential is a legitimate “brick” in the wall of one’s qualifications that can be carried and built upon, truly enabling “learning anytime, anywhere, by anyone” in line with Europe’s vision for lifelong learning

## 4.2. INTENDED USERS AND USE CASES (STUDENTS, LLL LEARNERS, CAREER SWITCHERS, HR PROFESSIONALS, EMPLOYERS)

### Upskilling Stories in Advanced Manufacturing

To make the concepts concrete, we present two realistic (albeit fictional) upskilling stories. These scenarios show how workers in the advanced manufacturing sector can leverage nano-credentials and the LCAMP platform to grow their careers – one starting from an entry-level position (EQF4) and another from a technician level (EQF4). Along the way, we highlight how the integrated pathway tool and micro-credential approach facilitate each step, and how this model can work across different European contexts.

#### Story 1: From Assembly Operator (EQF 4) to Robotics Technician (EQF 5)

Luca is a 30-year-old assembly line operator in an Italian automotive parts factory. He completed a secondary vocational certificate that is aligned with EQF level 3, giving him basic skills in machine operation and safety. Over the years, Luca has become an experienced operator, but he now sees automation transforming his workplace. His company is introducing collaborative robots (cobots) and even some metal additive manufacturing stations. Management has indicated that technicians with robotics and programming skills will be needed to maintain this new equipment. In fact, the LCAMP Skills Observatory reports that the shift to automated and digitalized processes like 3D printing requires retraining of existing staff for them to remain employable. Luca is motivated to upskill so he can secure one of the new Robotics Technician positions being created in his factory’s smart maintenance team.

Through the LCAMP platform, Luca accesses the Integrated Learning Pathway Tool to plan his next steps. He uses the tool’s self-assessment feature to profile his current skills. For example, he rates himself high in manual assembly and equipment operation, but low in areas like PLC programming or robot control (which he’s never done before). Next, Luca explores the job profiles in the system and finds “Robotics Maintenance Technician” – an occupation typically at EQF 5 in his industry. The profile shows key competencies required: e.g. understanding of sensors and PLCs, ability to program and troubleshoot robotic arms, knowledge of safety standards for automated systems, etc. Luca compares his profile to these requirements and the



tool automatically identifies skill gaps. As expected, he lacks training in programming and robotics. He also discovers he could improve his technical English to work with global documentation (another skill noted in the profile).

The pathway tool then recommends a personalized learning pathway for Luca, composed of several micro-credentials to fill these gaps. First, it suggests he start with a nano-credential on basic PLC programming (a 6-week online course) to build a foundation in controlling industrial machines. Next, it points to a “Fundamentals of Industrial Robotics” micro-credential, which covers how to operate and program collaborative robots safely. Notably, the micro-credentials are provided by institutions across Europe: the PLC course is offered by a Spanish partner institution, while the robotics course is run by an advanced manufacturing study programme in Germany. Thanks to LCAMP’s network of Centres of Vocational Excellence (CoVEs), Luca can access these learning opportunities remotely and earn digital certificates upon completion, which are aligned to ESCO skills and recognized via the European Digital Credentials framework. In the future, this kind of cross-border recognition is expected to become seamless, but even now the LCAMP partners envisage that Luca’s credentials are endorsed and can be trusted by employers or other training providers.

After a few months, Luca completes the two nano-credentials, each of which awards him a digital badge listing the learning outcomes he mastered. He updates his skills profile on the LCAMP tool, which now shows those newly acquired competences. At this stage, his profile match for the target job has improved significantly. The tool indicates he has only a couple of remaining gaps to reach the Robotics Technician profile. To address these, it recommends one more micro-credential: “Advanced Industrial Maintenance & Quality Control”, focusing on preventive maintenance for automated systems and data-driven quality techniques. This course is part of a Higher VET program (EQF 5) at a technical institute in Italy. Because Luca has already accumulated some credits from the earlier micro-credentials, he is able to enroll in the advanced course and even get partial credit recognition for the topics he covered online. In essence, his stack of nano-credentials is now contributing toward a formal Higher VET diploma in automation technology.

Luca’s employer is supportive of his upskilling plan – the company sees value in having an existing employee grow into the new role rather than hiring externally. With a combination of workplace practice and the LCAMP-facilitated courses, Luca gradually transitions into the Robotics Maintenance Technician position (now at EQF level 5). This is a big step up from his initial EQF3 qualification. He now not only operates machines, but also can program and maintain automated production lines. His pay and responsibilities increase accordingly. Importantly, Luca’s story shows how nano-credentials served as stepping stones: each addressed a specific skill requirement (PLC, robotics, etc.), and together they built up his competence profile to meet a real job opportunity. The LCAMP integrated pathway tool was key in guiding him – it matched training to the skills demanded by open job offers and emerging roles in the advanced manufacturing sector, ensuring that his effort translated into career advancement. What started as an unstructured desire to “learn something new” became a clear, structured pathway from an assembly operator to a qualified robotics technician, using stackable credentials as building blocks

## **Story 2: From Technician (EQF 4) to Manufacturing Engineer (EQF 6)**

Sofia is a skilled CNC machining technician from Germany, holding an apprenticeship diploma that is rated at EQF level 4. After several years in production, she aspires to move into a more engineering-oriented role, such as a Digital Manufacturing Engineer or production planner, which would typically require an EQF 6 qualification (equivalent to a bachelor’s degree).



However, as a working mother in her mid-30s, Sofia cannot afford to quit her job and enroll in a full-time university program. She needs a way to upskill gradually and flexibly, building on her existing professional competencies. This is where the integrated learning pathway approach becomes her game-changer.

Sofia turns to the LCAMP platform to chart a path toward her goal. Using the pathway tool, she finds a target profile called “Digital Manufacturing Engineer (Industry 4.0)” – a role that involves integrating IoT devices on the shop floor, analyzing production data, and optimizing processes for efficiency and sustainability. The tool analyzes the competencies required for this profile (e.g. data analytics, IoT systems, advanced process engineering, project management) and compares them with Sofia’s current skill set. Thanks to her strong vocational background, Sofia already has solid practical skills in machining and lean manufacturing, but she identifies gaps in areas like data analysis, cyber-physical systems, and advanced automation. The tool also highlights that knowledge of green manufacturing practices and digital simulation (digital twins) is increasingly important for such roles – aligning with industry trends toward sustainability and Industry 5.0 that the Observatory has noted.

To address these gaps, the LCAMP tool recommends a scalable learning pathway consisting of several sequential modules. Sofia’s journey begins with a nano-credential in “Industrial Data Analytics”, offered by a university of applied sciences in her region. This 8-week course teaches her how to interpret machine data and use analytics tools in a manufacturing context. Next, she enrolls in a micro-credential on “IoT and Cyber-Physical Systems for Smart Factories”, which is provided by a Finnish polytechnic via online delivery. This course gives Sofia exposure to connecting machines, sensors, and networks – crucial for implementing Industry 4.0 solutions. Because all these credentials are part of the LCAMP ecosystem, they come with academic credits and EQF level indications. Sofia accumulates credits that are recognized by the consortium of institutions. Each module she completes is like another rung on the ladder from EQF4 to EQF6.

Sofia’s progression is achieved step-by-step. After completing the initial nano-credentials, Sofia has effectively reached an intermediate milestone (EQF 5). In fact, the collection of credits from her data analytics and IoT courses, combined with some additional management module, enables her to earn a Diploma of Advanced Manufacturing Technology from a participating institute, within the LCAMP Alliance, which is an EQF 5 qualification. This intermediate credential boosts her profile; even before reaching EQF6, Sofia earns a promotion to Junior Process Engineer at her company’s manufacturing engineering department. Encouraged by this, Sofia continues to pursue the final leg of her pathway. With support from her employer and using mostly evening/weekend study (blended, remote), she embarks on a micro-degree program (still under the LCAMP umbrella) that focuses on Digital Production Management. Over the next year, she will complete advanced modules in sustainable manufacturing, production planning with digital twins, and a capstone project optimizing a process at her workplace. By the end of the journey, Sofia has accumulated enough credits for an Applied Bachelor’s Degree (EQF 6), awarded jointly by the network of CoVEs. Her new qualification and skills landed her a role as a Digital Manufacturing Engineer in a multinational company in a nearby country.

Sofia’s story underlines several powerful aspects of the integrated learning pathway. First, it demonstrates vertical mobility: she moved from a vocational level to a professional level (EQF4 to EQF6) by stacking credentials and without discontinuing her employment. Each nano-credential was not an isolated training, but part of a coherent plan that the LCAMP tool helped to map out. Second, the story shows the transnational dimension of the envisioned European model. Sofia could take courses from institutions in different countries (Germany, Spain, Slovenia and beyond) and have them all count towards her qualification, thanks to the alignment on EQF levels and (future) policy agreements. In the current state of practice, such recognition



often requires ad-hoc agreements – e.g. memoranda of understanding between institutions – to accept each other’s micro-credentials. LCAMP facilitates this through its partnership of vocational excellence centers, anticipating a future-model where Europe-wide standards (like the European Approach to Micro-Credentials) make it routine to transfer these credits. Finally, Sofia’s journey was guided by real industry needs: the skills she acquired (data analytics, IoT, etc.) were exactly those highlighted by the skills intelligence data as critical for modern advanced manufacturing roles. The payoff is evident in her improved career prospects.

### **Toward a Generalized European Model**

The examples of Luca and Sofia, while fictional, are grounded in the realities faced by many European workers in advanced manufacturing. They highlight how an integrated pathway tool and a micro-credential ecosystem can provide tangible, scalable pathways for upskilling and reskilling. National contexts – whether Italy’s focus on industrial technician diplomas or Germany’s strong apprenticeship system – can connect through a common framework (EQF) so that skills and credentials translate across borders. In the desired future model, a learner in any country could pick and choose modular learning opportunities from a European catalogue of micro-credentials and stack them toward recognized qualifications. This approach supports not only individual career development but also addresses skill shortages in the advanced manufacturing sector by quickly aligning training with industry demands.

Crucially, the LCAMP platform demonstrates how such a model can be implemented: by combining a skills-and-jobs observatory (to identify what is needed in the labor market) with a learning pathway tool (to guide learners to the right training). The use of nano-credentials as building blocks makes the learning journey customizable and scalable – someone can start at an EQF3 role and progressively move to an EQF5 or EQF6 role one micro-credential at a time. As Europe embraces the Council Recommendation on micro-credentials for lifelong learning (2022), the vision is that these small credentials will enjoy portability and trust across education systems and employers. The LCAMP initiative, through its deliverables D5.3 and D5.4, is effectively piloting this vision in the advanced manufacturing domain. By anchoring micro-credentials in a robust framework (with quality criteria, EQF alignment, and industry validation), and by providing user-friendly tools to navigate them, LCAMP is contributing to a future-ready skills ecosystem.

In summary, a learning pathway approach means a worker can continuously upgrade their skills in a piecemeal yet purposeful way – much like adding LEGO blocks to build a larger structure. Nano- and micro-credentials are those blocks, offering verified evidence of each skill acquired. The LCAMP platform acts as the blueprint, showing how the pieces fit together into larger career goals. This makes lifelong learning more approachable: instead of a daunting return to school, learners see a series of achievable steps. For advanced manufacturing in Europe, where technology leaps and green transitions are the new norm, this agile upskilling model is a promising strategy to keep the workforce competent, competitive, and resilient. The fictional journeys of Luca and Sofia exemplify how, with the right support, a technician today can become the high-tech manufacturing expert of tomorrow – one micro-credential at a time, on a pathway to success.



# 5. METHODOLOGY

## 5.1. APPROACH TO COLLECTING OCCUPATIONAL PROFILES

A structured methodology was used to create the underlying database of occupational profiles (with a target of approximately 700 profiles from different countries across the LCAMP consortium). All profiles were recorded and documented according to a common template and a uniform tagging procedure, taking into account the following guiding principles:

**Standardisation:** Each occupational profile corresponds to a uniform template with defined fields and a fixed format. This ensures the consistency and comparability of the profiles provided by different partners. Important information such as job title, description, required skills and qualifications are recorded in a standardised form. Standardisation was crucial for the aggregation of data at the European level.

**Validation by industry:**

The profiles are validated with the help of industry experts of each partner to ensure their relevance in practice. Each draft profile is reviewed by at least one representative of an AM company or industry specialist to ensure that the role, skills and competencies described correspond to the actual requirements in the workplace. This feedback loop helps to ensure that the content is accurate, up-to-date and in line with industry practices.

**Regional contextualisation:**

While maintaining a common format, the profiles reflect regional or national characteristics of the occupational roles. Partners in each country can adapt specific fields (e.g. typical job titles, legal qualification requirements) to ensure that the profile is meaningful in their context. This strikes a balance between standardisation and local relevance.

**Alignment with the LCAMP competence framework:**

All occupational profiles provided and processed on the platform are aligned with the LCAMP competence framework Deliverable 5.2 Skills Assessment Tool for Industry 4.0 and European classifications. The competences required for each profile are marked with reference codes from recognised frameworks (in particular ESCO and ISCO occupational competence descriptors). In addition, each profile is assigned an occupational category code (ISCO-08) to ensure international compatibility. This alignment means that users' competences and job requirements have a common language (e.g. the profile 'automation engineer' is linked to ESCO code 2141.4.2.1, so that a person's ESCO-coded competences can be matched to it). The qualifications in the profiles refer to EQF levels 3–6, which facilitates transparency of the required education levels in different countries.

**Integration of career paths:**

The template includes fields for specifying related career paths through ISCO-08 code, for example a junior 3D printing technician might have a senior 3D printing technician as a successor role.



### **Evidence-based data:**

Where possible, profile content is underpinned by labour market information, e.g. references to labour demand data or emerging skill requirements. Data collection drew on sources such as Cedefop's skills forecasts and sector studies to ensure that profiles reflect current and future trends. This evidence-based approach strengthens the credibility of the recommendations given to users.

ESCO/ISCO coding: Each job profile is coded using ESCO occupational categories (primary) and ISCO-08 (secondary). This alignment with European standardized occupation classifications ensures consistent categorization of roles and enables effective matching between learner skills and job requirements. The data structure follows European statistical standards for occupations, which improves interoperability with other systems and platforms that utilize these same classification frameworks. Following these principles, the LCAMP partners have jointly built an extensive library of Advanced Manufacturing (AM) occupational profiles. The work was distributed to cover the full range of occupations in the field: each VET/HVET partner contributed approximately 100 job profiles, structured through a collaborative approach. Of these, around 50 profiles were defined directly by the VET/HVET partners, reflecting their educational and training expertise; 30 profiles were contributed by associated partners, bringing additional sectoral and regional perspectives; and 20 profiles were defined in collaboration with industry partners, ensuring direct alignment with real labour market needs and company requirements.

This coordinated approach ensured broad and balanced coverage, resulting in a total of approximately 700 job profiles across different countries, Advanced Manufacturing sub-sectors (such as aerospace, automotive, and machine tools), and qualification levels spanning EQF levels 3 to 6.

A coordination table (managed by TKNIKA) recorded the contributions to avoid duplication and to verify that all major categories were being addressed. By Month M44, the consortium successfully compiled a comprehensive job profile database representing the advanced manufacturing landscape Europe-wide.

## **5.2. PLATFORM DEVELOPMENT AND INTEGRATION**

In parallel with data collection, the technical development of the tool proceeded in incremental phases. The implementation followed an agile approach with frequent iterations to integrate various components (assessment toolkit, databases) and refine functionality. Key steps included:

Initial Prototype and Integration of Existing Tools: The development team (led by KIC, with DHBW) started by finalizing the data model and user interface design in early 2025. A Version 1 prototype of the platform was completed by mid-June 2025, focusing on back-end integration of D5.2 and D5.3 outputs. This included embedding the Skills Assessment Toolkit into the platform's front-end (so users can take a self-assessment quiz online) and importing the micro-credentials/course database into the system's repository. Basic search and matching algorithms were implemented to connect user assessment results to job profiles and training courses. By this stage, the job profile template was finalized (end of May 2025) and used to structure the database schema.



**Data Population Phase:** Once the structure was in place, the platform was prepared to ingest the job profile data collected by partners. From July 2025, as partners began submitting profiles (via an online form or CSV import), the development team continuously updated the database and improved the interface for browsing profiles. By the final submission deadline (Nov 30, 2025), the platform hosted profiles in all six languages, with over 700 entries as planned. The development included features to support multilingual data entry, such as fields for multiple language versions of a profile’s title and description.

**Feature Implementation:** The tool’s key functionalities (skills-gap analysis, job matching algorithm, learning recommendation engine, etc.) were developed and tested incrementally. For example, the skills matching algorithm uses the vector of ESCO skill identifiers from a user’s self-assessment to find profiles requiring those skills, and computes a “fit score” that ranks potential job matches. Similarly, the recommendation engine queries the courses database (D5.3) for training that covers the missing skills for a chosen profile. A recognition/credential pathway module was also implemented: this guides users on how certain micro-credentials can be accumulated or recognized towards formal qualifications (linking to the European Credit system where applicable). Throughout development, interoperability was ensured by building an API layer – for instance, exposing job profile data via JSON for reuse in other services, and enabling import/export in standard formats (JSON-LD or XML) compliant with the Europass/EDC data model.

**Iterative Refinement:** The development was iterative, incorporating feedback from internal testers and external users (see 3.5 below). An alpha version (internally tested by the consortium) helped identify initial bugs and user experience issues by late January 2026. A beta version (with more complete features and dataset) was released to a group of pilot users by January 2026 for broader testing. Each iteration cycle (roughly corresponding to 1-month sprint) involved refining the user interface, improving performance (page load times, search speed), and enhancing matching accuracy. Development continued into late 2025 and early 2026 to finalize all features and ensure the tool met all requirements by the delivery date.

## 5.3. SKILL PROFILING & RECOMMENDATION ENGINE

The Skill Profiling and Recommendation Engine serves as the foundation for creating personalised learning pathways and career advancement opportunities for learners. To effectively recommend relevant upskilling opportunities and career paths, the system must first understand what skills the learner already possesses and at what level of proficiency.

The skill profiling process begins by identifying which skills a learner possesses using the skill taxonomy and terminology established in the LCAMP Framework (as defined in D5.1). This identification occurs through two primary methods:

1. **Document Analysis:** the system analyses uploaded documents such as CVs, resumes, certificates, and formal credentials to extract relevant skills.
2. **Self-Identification:** learners can directly indicate skills they possess through the platform interface.

Once skills are identified, the system determines the proficiency level for each skill. Skill proficiency is the degree of mastery someone has developed in performing a particular skill,



encompassing their knowledge of underlying concepts, technical ability to execute tasks, speed and efficiency, problem-solving capacity, independence, and consistency across varied contexts.

The system employs a four-level proficiency scale:

- **Level 1 - Beginner:** Foundational understanding and basic task execution
- **Level 2 - Intermediate:** Independent application of skills in familiar contexts
- **Level 3 - Advanced:** Mastery of complex scenarios and optimization capabilities
- **Level 4 - Expert:** Innovation, thought leadership, and ability to extend the field

Proficiency levels are determined through a self-assessment questionnaire (detailed in D5.2), where learners evaluate their capabilities against descriptors aligned with each proficiency level for their identified skills.

The result of the skill identification and proficiency assessment process is a comprehensive Skill Profile — a structured representation of the learner's capabilities. In figure 1 The Skill Profile is visualised as a matrix mapping each identified skill to its corresponding proficiency level.

Identified Skill	Beginner	Intermediate	Advanced	Expert
3D modelling				✓
3D printing process				✓
Adjust machine parameters			✓	
Apply precision metalworking techniques		✓		
Interpret 3D plans				✓
Interpret technical documentation			✓	
Operate welding equipment	✓			
Plan manufacturing processes		✓		
Operate control systems			✓	
Read standard blueprints			✓	

Note: Proficiency levels are indicated by checkmarks (✓) in the corresponding column.

Figure 1: Example skill Profiler Output for 3D Technician

The Skill Profile serves as the input for the recommendation engine, which employs a matching algorithm to generate two types of recommendations: job position recommendations and learning opportunity recommendations.



Job positions within the system are defined using the same structured format as Learner Skill Profiles, specifying required skills and the minimum proficiency level needed for each skill.

Job position recommendations are generated by comparing Learner's Skill Profile against job position requirements looking for jobs with the greatest degree of overlap. This allows learners to discover positions where they already possess substantial relevant expertise.

Microcredentials in the system are defined using the same skill-proficiency structure, specifying which skills they develop upon completion (detailed in D5.3).

Learning opportunities recommendations are generated by addressing skill gaps—the difference between a learner's current profile and the requirements of target positions. While job matching identifies where learners currently qualify, learning opportunities focus on what needs to be developed. The gap analysis identifies missing skills required by target jobs that the learner does not possess and those the learner possesses at a lower proficiency level than required. Recommendation algorithm matches microcredentials to identified gaps, providing learners with relevant and clear pathways to develop the expertise needed for their target positions.

This structured approach to skill profiling and recommendation provides several key advantages:

- Objectivity: Standardised skill definitions and proficiency levels reduce ambiguity.
- Personalisation: Recommendations are tailored to each learner's unique profile and goals.
- Transparency: Learners can see exactly which skills they need to develop and how.
- Efficiency: The system identifies the most direct paths to career objectives.
- Continuous Adaptation: As Learners acquire new skills and document their learning achievements, their profiles update accordingly, with the tool providing new recommendations aligned with their advancing expertise.

More information about how the tool guides the user through Skill Profiling can be found in section 6 of this document. For a more detailed technical explanation on the skill matching algorithm can be found in Deliverable 8.1 LCAMP Development Roadmap.

## 5.4. VALIDATION APPROACH AND QA PLAN

### 5.4.1. QUALITY ASSURANCE PROCESS FOR PROFILE CONTENT

To maintain high-quality data across all profiles, the partnership implemented a multi-stage quality assurance process:

1. **Initial Verification:** TKNIKA and DHBW reviewed submitted profiles for completeness and conducted initial quality checks against agreed criteria:



- a. Completeness (all mandatory fields completed)
  - b. Consistency (terminology followed established conventions)
  - c. Clarity (descriptions were understandable to target users)
  - d. Accuracy (alignment with relevant industry standards)
2. **Industry Validation:** Job profiles were validated with external industry representatives to confirm real-world relevance by each partner.
  3. **Data Consistency Check:** Automated checks were applied to verify structural consistency and compliance with the framework, including:
    - a. Format validation and reference integrity (e.g., links to skills framework elements) during data input
    - b. Language consistency
    - c. Duplication detection when entering job titles, to flag potential overlap with existing profiles
  4. **Final Approval:** TKNIKA provided final approval before profiles were integrated into the deliverable dataset and reported in this deliverable.

## 5.4.2. SKILL PROFILING AND RECOMMENDATION ENGINE

The Skill Profiling and Recommendation Engine requires rigorous validation to ensure it accurately identifies skills, appropriately assesses proficiency levels, and generates relevant recommendations. The validation approach encompasses multiple testing phases and quality assurance mechanisms throughout the development and deployment lifecycle.

### Development Phase Validation

During the planning and development phase, feedback was actively collected through sprint meetings within WP8 (platform development sprints). This iterative approach allowed the development team to continuously refine the skill extraction algorithms, proficiency assessment mechanisms, and matching logic based on regular stakeholder input. Sprint reviews provided opportunities to demonstrate functionality, gather feedback on user interface design, and validate that the Skill Profiling & Recommendation Engine aligned with project requirements and user needs before full implementation.

### Technical Validation

The skill extraction algorithms underwent systematic testing using a diverse corpus of CVs, credentials, and professional documents to verify accurate skill identification and proper mapping to the LCAMP Framework.



## **User Validation**

Pilot testing with representative learners from different professional backgrounds and experience levels provides critical feedback on the usability and perceived accuracy of skill profiling. Participants complete the skill identification and proficiency assessment process, then evaluate whether the resulting Skill Profile accurately reflects their capabilities and provides feedback on the tool usefulness. User validation was conducted as part of WP8 development.

## **Continuous Quality Assurance**

Post-deployment, the system employs ongoing monitoring mechanisms to maintain recommendation quality. User feedback mechanisms allow learners to rate the relevance of recommendations, flag inaccuracies in skill extraction, and report discrepancies in proficiency assessments. This process will be ongoing through the bug tracker whereby anyone can report an issue through the LCAMP platform available at: <https://lcamp.eu/issue-tracker/> which triggers an alert to the to resolve the matter. System analytics track key performance indicators including recommendation acceptance rates, learning pathway completion rates, and post-training skill advancement. This data informs iterative refinements to the extraction algorithms, proficiency descriptors, and matching logic. Regular audits ensure the skill taxonomy remains current with evolving industry requirements and that newly added microcredentials and job positions are properly mapped to the LCAMP Framework.



# 6. SKILL PROFILER USER JOURNEY FIGURE

## 6.1. LEARNER PORTAL DASHBOARD

This screen demonstrates the Learner Portal landing/dashboard for a newly registered user with no completed Skill Profile. The interface presented a clear empty-state message and a prominent call-to-action (“Skill Profiler > Start”), guiding the learner to initiate the profiling workflow.

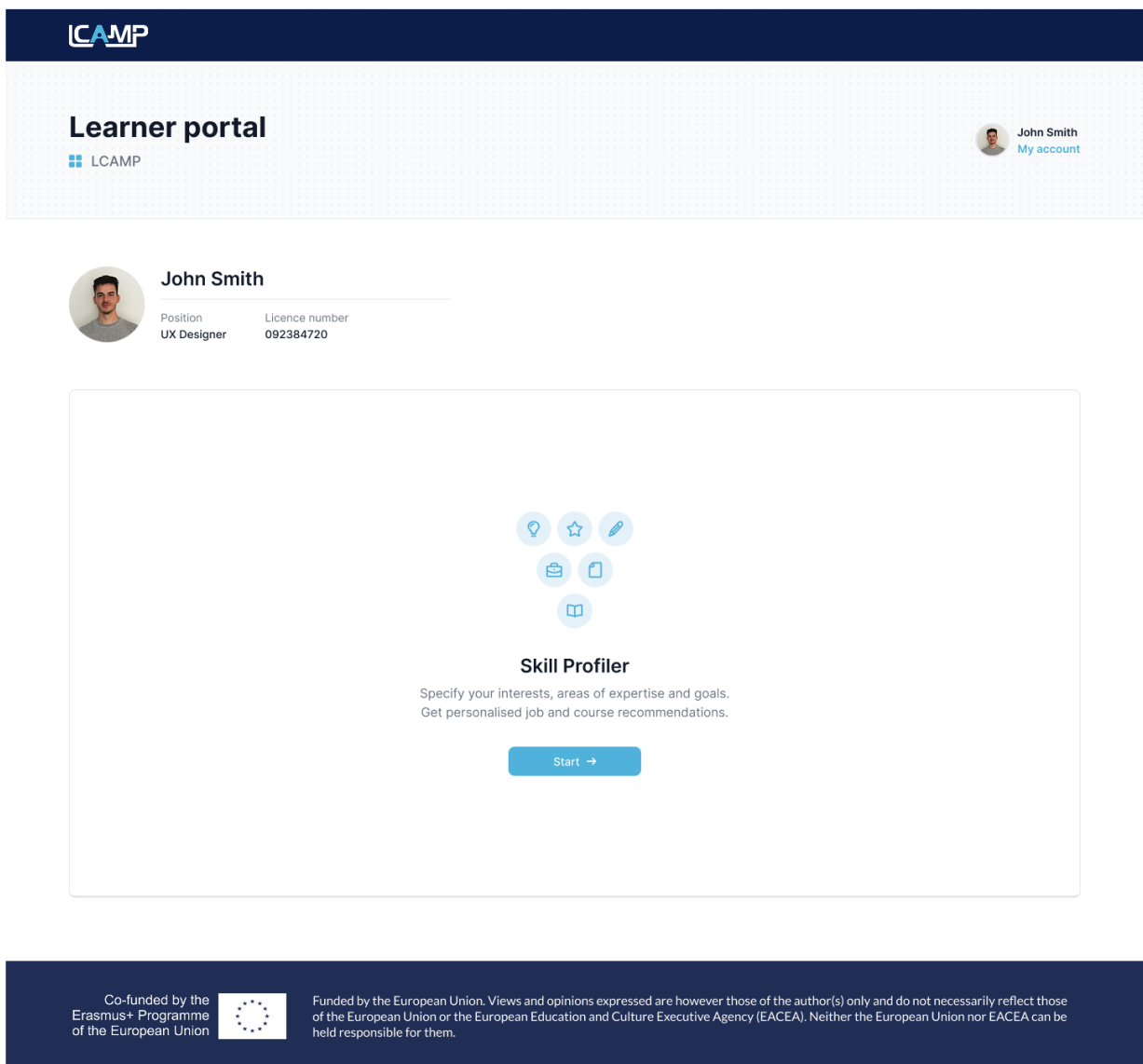


Figure 2: Learner portal Dashboard



## 6.2. SKILL PROFILER STEP S1.1: INTEREST CAPTURE

This screen represents the first step of the Skill Profiler journey, where learners entered free-text inputs describing their interests and career direction. Guidance text and examples supported consistent inputs while allowing natural language, which was later used for AI-supported classification and recommendation. Alternatively, the user may manually select interest area from a list.

The screenshot displays the LCAMP Learner portal interface. At the top, the LCAMP logo is visible. Below it, the 'Learner portal' section shows the user's name 'John Smith' and a link to 'My account'. The main content area is titled '2 Your interests' and includes the instruction 'Help us understand your career interests'. A text input field contains the example text: 'E.g: I'm interested in working with data and creating visualizations. I enjoy solving problems and working with technology...'. Below the input field, there are suggestions for inspiration: 'Working with technology and coding', 'Helping people and solving their problems', 'Creative design and visual communication', and 'Business strategy and leadership'. A link 'I'd rather select my interests from a list' is also present. At the bottom of the form, there is a 'Continue' button with navigation arrows.

Figure 3: Step S1.1: Interest capture



## 6.3. SKILL PROFILER STEP S1.4: CONFIRM AI-INFERRED INTERESTS

This screen showed the human-in-the-loop validation mechanism applied after AI inference. Based on the learner's prior text input, the system displayed suggested areas of interest (e.g., selectable chips/checkboxes such as "3D modelling", "Augmented reality", "Artificial intelligence"). The learner could confirm, adjust selections, or repeat the previous step if none were correct. The interest areas correspond to competence framework categories defined in D5.1 and inform the recommendations done by the tool.

The screenshot displays the LCAMP Learner portal interface. At the top, the LCAMP logo is visible. Below it, the text "Learner portal" and "LCAMP" are shown. On the right, a user profile for "John Smith" with a "My account" link is displayed. The main content area is titled "2 Your interests" and includes the instruction "Help us understand your career interests". A message states: "We discovered these areas of interest based on your input. Confirm whether our assessment was accurate by checking the correct areas of interest". Below this, three selectable options are shown: "3D modelling" (checked), "Augmented reality" (checked), and "Artificial intelligence" (unchecked). A link at the bottom of the selection area reads "None of these fit my interests (repeat previous step)". A "Continue" button with left and right arrows is located at the bottom of the form.

Figure 4: Step S1.4: Confirm AI-inferred interests



## 6.4. SKILL PROFILER STEP S2.1: UPLOAD EXPERIENCES

On this screen the learners define their past experiences through two flexible input methods: by uploading documents (CVs, resumes, diplomas, certificates), or by manually entering their experience using free text descriptions of work history, education, projects, and other relevant activities. Both methods leverage AI-powered parsing to extract professional experience, educational background, and skills, automatically mapping all extracted information to the LCAMP Framework.

**LCAMP**

**Learner portal**  
LCAMP

John Smith  
My account

**3 Your experiences**  
Help us understand what you're already skilled in, by uploading your CV, diplomas, micro-credentials or other certifications.

**Describe your past work experiences and upload documents about your experience.**  
Describe your work experiences with your own words. Upload your CV and any certifications you might have. We will parse your input with AI to extract your skills.

E.g: I worked with data and created visualizations. (Optional)  
0 / 500 characters

Drag your CV, diplomas, micro-credentials and other certificates here  
Accepted formats: .xml, .pdf (Max. 10 MB)  
or  
Browse files

← Continue → I don't have any

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Figure 5: Step S2.1: Upload experiences



# 6.5. SKILL PROFILER STEP S2.2: CONFIRM AI-EXTRACTED EXPERIENCE DATA

After the system processes uploaded documents or entered experience data, learners are presented with a list of extracted skills for review and validation. The interface allows learners to confirm, edit, or remove AI-identified skills and add any skills that were not automatically detected. Once the skill list is validated, learners self-assess their proficiency level for each confirmed skill using descriptors aligned with the four proficiency levels (Beginner, Intermediate, Advanced, Expert). This combined confirmation and assessment process ensures that the resulting skill profile accurately reflects both the skills learners possess and their level of mastery in each.

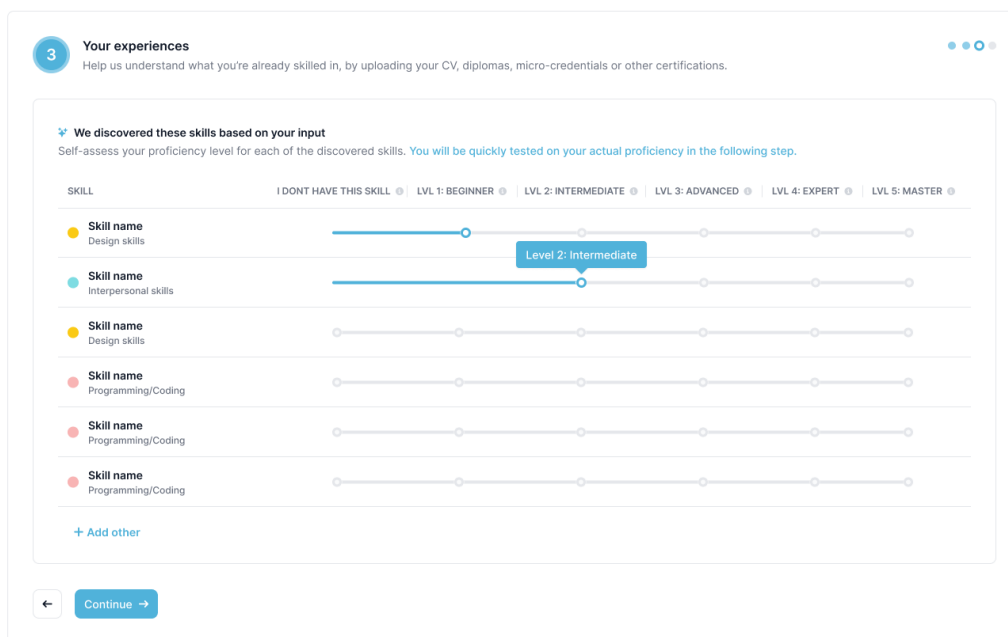
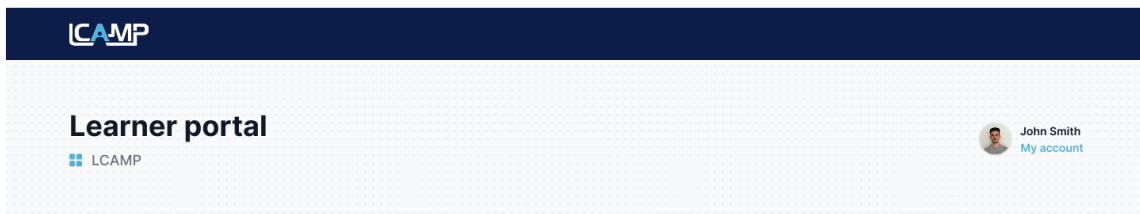


Figure 6: Step S2.2: Confirm AI-extracted experience data



## 6.6. SKILL PROFILER STEP S3.2: SKILL EVALUATION

To ensure accuracy of the self-assessed proficiency levels, learners proceed through a validation questionnaire featuring structured prompts and level-of-experience statements for specific skills. This stage presents competency scenarios that allow learners to verify their initial proficiency selections against concrete examples of what each level entails. This validation step enhances the reliability of the skill profile by encouraging learners to reflect more deeply on their actual capabilities.

The screenshot displays the LCAMP Learner portal interface. At the top left is the LCAMP logo. The main heading is "Learner portal" with a sub-label "LCAMP". On the right, a user profile for "John Smith" is shown with a "My account" link. Below this is a "Skill evaluation" section, labeled "4", with the instruction: "Try to answer the questions correctly in order to confirm your selected proficiency levels." A progress bar at the top of the evaluation area shows proficiency levels for C#, Figma, HTML, Javascript (currently "NOW EVALUATING"), Adobe XD, Figma, and C#. The current question is "QUESTION 2 OF 5" and asks: "You're modeling a character arm that will be rigged and animated. You've created clean geometry around the elbow, but when the animator bends the arm to 90 degrees, the geometry collapses inward and looks pinched. What is the most likely cause?" Four radio button options are provided: "The UV map is overlapping, causing texture distortion during deformation.", "The topology around the joint doesn't have enough edge loops running perpendicular to the bend axis, preventing proper deformation." (which is selected), "The model's vertex normals are pointing inward instead of outward.", and "The polygon count is too high, causing the real-time engine to struggle with skeletal animation." A "Continue" button is at the bottom.

Figure 7: Step S3.2: Skill evaluation



## 6.7. SKILL PROFILER STEP S3.3: SKILL EVALUATION FINAL REPORT

This screen presented the consolidated Skill Profile output following evaluation. The interface summarised results visually (e.g., high-level indicators/charts and grouped skill areas) and supported onward navigation (e.g., proceeding to recommendations or returning to the dashboard). This step served as the learner-facing “results” layer before job suggestions were displayed.

The screenshot shows the 'Skill evaluation' final report interface. At the top, the LCAMP logo is visible. Below it, the 'Learner portal' header includes the LCAMP logo and the user's name 'John Smith' with a 'My account' link. The main content area is titled '4 Skill evaluation' and includes a progress indicator. A success message states 'Evaluation complete! Great work! Your skill profile is now validated and ready to match you with opportunities.' Summary statistics show 'Skills evaluated: 15' and 'Average proficiency: 3.2 / 5'. The 'Strongest skill' is 'JavaScript' and the 'Strongest area' is 'Programming/coding'. A tip indicates that the full skill profile is accessible after completing the profiler. Two skill categories are detailed: 'Design skills' (2 out of 5 skills) and 'Programming/Coding' (4 out of 5 skills). Each category lists skills and their proficiency levels, with 'Figma' and 'Adobe XD' under Design skills, and 'JavaScript' and 'PHP' under Programming/Coding. A 'See your job recommendations' button is at the bottom.

**LCAMP**

**Learner portal**

LCAMP

John Smith  
My account

**4 Skill evaluation**  
Try to answer the questions correctly in order to confirm your selected proficiency levels.

**Evaluation complete!**  
Great work! Your skill profile is now validated and ready to match you with opportunities.

Skills evaluated: 15 | Average proficiency: 3.2 / 5

Strongest skill: JavaScript | Strongest area: Programming/coding

You can access your full skill profile after completing the skill profiler

**Design skills**  
2 out of 5 skills

SKILLS	PROFICIENCY LEVEL
Figma	★★★★★ Self-assessed
Adobe XD	★★★★ Self-assessed

**Programming/Coding**  
4 out of 5 skills

SKILLS	PROFICIENCY LEVEL
JavaScript	★★★★★ Self-assessed
PHP	★★★★★ Self-assessed

See your job recommendations →

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Figure 8: Step S3.3: Skill evaluation final report



## 6.8. SKILL PROFILER STEP S4: JOB PROFILE RECOMMENDATIONS

This screen showed the recommendation engine output. Job profiles were displayed as structured cards (e.g., job title and level), including:

- Role description and responsibilities,
- Required skills with a visual indicator for satisfactory / missing / not required proficiencies, and an overall match percentage (e.g., “90% match”).
- A clear control enabled learners to navigate back to view the full skill profile on the dashboard, supporting iterative improvement (i.e., identify missing skills and revisit profiling or learning pathways).

The screenshot displays the LCAMP Learner portal interface. At the top, the LCAMP logo is visible on the left, and the user's name 'John Smith' with a 'My account' link is on the right. The main content area is titled 'Learner portal' and features a 'Job profile recommendations' section. This section contains a card for a 'Junior Backend developer' role. The card includes a description of the role, a list of responsibilities, and a 'Required skills' section with proficiency indicators for Javascrript, HTML, CSS, PHP, and React. A '90% match' score is displayed. A button at the bottom of the card allows the user to 'See full skill profile on the dashboard'. The footer of the page contains funding information from the Erasmus+ Programme and the European Union.

Figure 9: Step S4: Job profile recommendations



## 6.9. LEARNER PORTAL DASHBOARD (POPULATED STATE)

Upon completing the skill profiling process, learners are presented with a comprehensive dashboard providing an analytics-style overview of their skill profile. The dashboard displays charts and summarized indicators showing their validated skills, proficiency levels across different competency areas, and overall profile completeness. From this central hub, learners can access their personalized job recommendations and learning opportunities, both generated through the matching algorithms described in Section 5.3.

The dashboard serves as the learner's ongoing home view within the platform, enabling continuous engagement beyond the initial profiling. Learners can update their profiles at any point by uploading new experiences, CVs, or credentials, which triggers re-analysis and updated recommendations. Additionally, as learners complete recommended courses or microcredentials, they can mark these achievements as complete within the system. Upon marking a learning opportunity as complete, the associated skills are automatically assigned to the learner's profile at the appropriate proficiency level, immediately updating their skill profile and triggering recalculation of job matches and learning pathway recommendations. This continuous adaptation ensures the tool remains relevant throughout the learner's career development journey.



**John Smith**

Position: UX Designer  
Licence number: 092384720



**Interests and experience**

**Your interests** Edit

I like to build three-dimensional digital objects for games, films, and commercial projects—everything from photorealistic renders to stylized characters. My work involves sculpting geometry, understanding topology so models deform properly when animated, and obsessing over surface details like seams and wear patterns. A huge part is technical problem-solving: optimizing polygon counts, unwrapping UV maps, debugging why geometry behaves unexpectedly. I spend significant time iterating with art directors based on feedback, which tests my patience but ultimately produces better work.

3D modelling   Augmented reality   Artificial intelligence

**Your experience - 2** Edit

- CV.pdf (200 KB)
- Microcredential.xml (200 KB)

Figure 10: Learner portal 1



## Your skills

Assess multiple →

Filter ▼
Sort by: Proficiency level ▼
All
Assessed
Not yet assessed

SKILLS	UPSKILLING OPPORTUNITIES	YOUR PROFICIENCY LEVEL	ASSESS
PHP Programming/Coding		●●●●● Self-assessed	Verify →
PHP Design skills	Upskilling opportunities available >	●●●●● Self-assessed	Verify →
PHP Programming/Coding	Upskilling opportunities available >	●●●●● Self-assessed	Verify →
PHP Interpersonal skills	Upskilling opportunities available >	●●●●● AI assessed	Assess now →
PHP Business skills	Upskilling opportunities available >	●●●●● AI assessed	Assess now →
PHP Design skills	Upskilling opportunities available >	●●●●● Verified	No action required
PHP Programming/Coding		●●●●●	Assess now →
PHP Design skills		●●●●●	Assess now →
PHP Business skills		●●●●●	Assess now →
PHP Programming/Coding		●●●●●	Assess now →

Showing 1-10 of 20
Previous Page 1 of 2 Next

**AI assessed**

The proficiency of this skill was determined by AI. Complete the assessment quiz to get a more accurate proficiency rating.

Figure 11: Learner portal 2

### We identified these learning opportunities for you

Recommended
Completed

**PHP for Beginners**  
Ljubljana, Slovenia (Hybrid) · English · EQF 5 · 20 ECTS

PHP ●●●●● Coding ●●●●● HTML ●●●●● Javascript ●●●●●

**Learn Figma in 30 days**  
Brno, Czechia (In-person) · English · EQF 5 · 5 ECTS

Work collaboratively ●●●●● Figma ●●●●● UX Design ●●●●●  
UI Design ●●●●●

**Advanced Python Programming**  
Berlin, Germany (Online) · German · EQF 5 · 30 ECTS

Python ●●●●● Data Science ●●●●● Machine Learning ●●●●●  
Algorithms ●●●●●

**Introduction to UX Design**  
Barcelona, Spain (In-person) · Spanish · EQF 5 · 25 ECTS

UX Design ●●●●● User Research ●●●●● Prototyping ●●●●●  
Wireframing ●●●●●

### We identified these job profiles for you

**Backend developer** Junior 90% match

Javascript ●●●●● PHP ●●●●● CSS ●●●●● React ●●●●●  
HTML ●●●●● +3 more

**Backend developer** Junior 90% match

Javascript ●●●●● PHP ●●●●● CSS ●●●●● React ●●●●●  
HTML ●●●●● +3 more

**Backend developer** Junior 90% match

Javascript ●●●●● PHP ●●●●● CSS ●●●●● React ●●●●●  
HTML ●●●●● +3 more

**Backend developer** Junior 90% match

Javascript ●●●●● PHP ●●●●● CSS ●●●●● React ●●●●●  
HTML ●●●●● +3 more

Figure 12: Learner portal 3



More information on the Tool Architecture and Functional Design is available in Deliverable 8.1 (LCAMP Platform Roadmap).

## 7. IMPLEMENTATION ROADMAP

### 7.1. WORK PLAN AND IMPLEMENTATION TIMELINE

The work plan for the development of D5.4 (the integrated learning path tool and accompanying report) was implemented from approximately May 2025 to February 2026, following a series of defined phases and milestones. The schedule was carefully structured to ensure timely delivery by the end of the project (month 44). Each phase had clear tasks, responsible partners and deliverables. Below is an overview of the implementation schedule and key activities:

**Initial development and planning (May – June 2025):** This preparatory phase focused on laying the groundwork. The team completed the template for the job profile and data structure by the end of May 2025. A project meeting (mid-May in Sweden) officially launched the work on D5.4 and aligned all partners on the methodology and their roles. By mid-June, version 1 of the platform was completed, which included the integration of the competence assessment tool (D5.2) and the micro-certificate database (D5.3) into a basic working prototype. In addition, a training video was produced on 16 June 2025 to show partners how to enter data into the system and use the preliminary tool. During this phase, the technical foundations were laid and the partners were prepared for data entry.

**Data collection phase (July – November 2025):** This was the intensive phase of collecting and entering occupational profile data. From 1 July 2025, all partners began providing profiles according to their allocation (see section 3.1). The plan was for each vocational training partner to provide around 50 profiles and each industry partner around 20 profiles (plus around 30 from associated partners), making a total of over 7

00. The partners were trained in the use of the online template or batch upload via CSV. Progress was assessed in an interim evaluation on 15 September 2025 – by this date, around half of the profiles (over 400) should have been submitted. Partners who were lagging behind or had quality issues received feedback. The final deadline for submitting profiles was 1 November 2025. By this date, all profiles should have been entered in all six languages. In the meantime, the development team continued to refine the platform's features. This phase was successfully completed with the filling of the database (in some cases, partners even exceeded the targets and achieved a diverse selection of profiles), creating the conditions for a thorough review and testing phase.

**Quality assurance and improvement (August – November 2025):** Parallel to data collection, continuous quality assurance took place from August to the end of October 2025. As described in section 3.3, the profiles were reviewed and improved. By 14 November 2025, comprehensive quality assurance was carried out for the entire data set to ensure that >95% of the profiles met the quality standards. In parallel, the functionality of the platform was gradually improved and internal tests (alpha) were carried out. In October 2025, the team also began compiling the documentation for the results report (e.g. writing the methodology, recording the interim results),



with the draft report structure completed by 15 October. This phase focused on optimising both the content and the tool for external presentation.

Test and pilot phase (February 2026):

After quality assurance, the tool is ready for pilot testing with end users. Pilot tests are planned with selected vocational schools and industry partners from across the consortium, where users will try out all key features (skills profiling, job matching, course recommendations, etc.) and provide feedback. This pilot phase will also serve to raise awareness of the tool among key stakeholders and identify any refinements needed before broader deployment. The development process documented in this deliverable (D5.4) culminates on 14 January 2026 with the completion of this development report, which summarizes the design, implementation, and initial readiness of the Skill Profiling & Recommendation Engine for use within the LCAMP platform.

## 7.2. RISK-MANAGEMENT, TESTING, FEEDBACK LOOPS, AND ITERATIVE QUALITY ASSURANCE

The development and deployment of the Integrated Learning Pathways Tool involved managing several risks to ensure successful delivery. The development team has identified key risks and planned mitigation strategies for each. Below, we summarize the main risks encountered and how they were addressed:

### **Insufficient Partner Engagement – Risk:**

Some partners might under-deliver on their commitments (e.g., not contributing the expected number of job profiles or not participating actively in testing). Impact: High, because without broad data input and feedback, the tool's content and relevance would suffer. Probability: Estimated medium initially, as partners have many parallel tasks. Mitigation: We closely monitored partner contributions through early and frequent tracking. Weekly progress reports were automatically generated, showing profiles submitted by each partner. This transparency created positive pressure. Responsibilities were clearly allocated, and WP leaders followed up individually when needed. We also kept the task visible. As a result, all partners delivered or even exceeded their profile quotas by the final deadline.

### **Data Quality Issues – Risk:**

The job profiles submitted might be inconsistent in quality – some incomplete, inaccurate, or not following the template. Impact: High, as poor data would undermine the tool's recommendations and credibility, given the varying expertise across contributors. Mitigation: We implemented the multi-stage quality assurance process described in Section 3.3, including initial checks and peer reviews. We gave partners clear guidelines and a template example from the start to minimize confusion. Frequent feedback loops meant issues were corrected early. Automated validation in the data entry form (e.g., cannot submit if mandatory fields blank) would have been the best option, but wasn't feasible.



The QA team regularly communicated common mistakes (like lacking entries) to all partners so they could improve subsequent entries. These actions ensured a uniformly quality of profile data by the end.

Despite these multiple phases of quality assurance and evidence-based use of data, the data on occupational profiles and aggregated skill sets must be considered inherently subjective. This is largely due to the differing tagging approaches used by consortium partners in WP5 and the varying individual interpretations of national skills and job profiles. The accuracy of the dataset ultimately depends on the judgment of the individuals who entered the information.

Because the platform's data is based on these subjective tagging procedures (inputs), the job profiles will require ongoing updates and refinements to prevent bias and obsolescence. Establishing a robust quality framework to standardize and improve tagging methodologies is strongly recommended as the next step.

#### **Technical Development Delays or Challenges – Risk:**

The software development might face delays (e.g., due to underestimation of complexity) or technical issues in integrating components. Impact: High, as a delay could jeopardize meeting the Month 44 deadline, and technical failures could reduce functionality. Probability: Medium. To mitigate the risk, WP5v followed an agile development approach with spontaneous sprints. By breaking development into smaller iterations, we identified challenges early (for instance, initial integration of D5.2 needed adjusting to the new interface). WP5 prioritized core features first (assessment, matching, etc.) to ensure a minimum viable product was ready on time, leaving non-essential enhancements for later or post-project if needed. Moreover, WP5 also did early prototyping of high-risk elements (like the multilingual implementation) to gauge effort and avoid last-minute surprises.

Providing quality translations and a fully multilingual interface might be more difficult or time-consuming than expected (e.g., idiomatic expressions in profiles not translating well, or interface layout breaking with longer words). Impact: Medium – it affects user experience in non-English contexts. The development team prioritized the user-facing interface translation early, focusing on clarity and hiring professional translators for critical text. For profile content, we used a combined approach: automated translation followed by review by native speakers (partners) for accuracy. This distributed the effort and caught errors. WP5 team members engaged bilingual staff in each country to validate terms, especially technical jargon. Our strategy allowed phased translation – we ensured at least summary info was translated for all profiles by launch, with full detail translation to follow if needed. We also built flexibility in the UI to handle text expansion (for languages like French or Turkish which can be longer). Through testing, we ironed out layout issues early. Ultimately, while some translation tasks were labor-intensive, the risk was managed and we delivered a functioning multilingual tool.

#### **Low User Adoption:**

After development, there might be limited uptake – e.g., few learners or institutions use the tool (perhaps due to lack of awareness or perceived complexity). Impact: High, since the success of the deliverable is tied to usage. Probability: Assessed as low, given our dissemination plans, but still a concern. Mitigation: We tackled this from the start by engaging users in design and testing (Section 3.5) – this not only improved the tool but also created early advocates who will promote it. Our dissemination strategy (Section 6) is robust, ensuring widespread awareness at launch (with events, press, social media). To ease adoption, we produced user-friendly guides. The tool is also free and open to all, removing access barriers. Additionally, we integrated it with existing LCAMP services (like the main platform login), making it simpler for the Alliance members to start using it. These steps collectively lower the threshold for use.



### **Data Integration with Other Systems – Risk:**

WP8 ensured early on that the tool’s design is modular and uses standard data formats for any exchange. WP5 coordinated with WP8 teams to define data exchange requirements. We also tested embedding the tool’s widget into the main LCAMP portal to ensure single sign-on and a smooth user journey. Essentially, by using open standards and continuous communication between WPs, we prevented integration issues. Additionally, our documentation includes clear instructions for any future integrators on how to connect with our system. This risk turned out to be minimal as integration went smoothly in final testing.

In summary, risk management was an active part of WP5 execution. We identified potential issues early in the Work Plan and implemented mitigation measures proactively. These efforts have paid off: none of the identified risks materialized to a degree that impeded the deliverable. Partner contributions were on target, data quality is high, the tool was delivered on time, is fully multilingual, and the integration with the LCAMP ecosystem is successful.

Of course, the quality of the data is subject to individual tagging standards delivered on institutional level. Adoption beyond the project timeframe would involve continuous dissemination and support (handed over to the Alliance). But as of project completion, we can report that all major risks have been mitigated to acceptable levels, and contingency plans were ready (though largely not needed). This risk management approach ensured that D5.4 achieved its objectives without major setbacks.

## **8. CONCLUSION AND OUTLOOK**

### **8.1. FORWARD-LOOKING**

#### **PERSPECTIVE: PATHWAYS TO RECOGNITION, SCALING, AND SUSTAINABILITY**

In conclusion, Deliverable D5.4 – the Integrated Learning Pathways Tool for Lifelong Learning – has been successfully developed and deployed, fulfilling a central ambition of the LCAMP project to provide a learner-centric, data-driven platform for advanced manufacturing skills development.

This Development Report has detailed the journey of building the tool: from initial methodology design through data collection, integration of prior deliverables (D5.2 and D5.3), rigorous quality assurance, to testing with end-users and preparing dissemination. The resulting tool connects the dots between individual skill profiles, industry-defined job requirements, and targeted learning opportunities (including micro-credentials), thereby operationalizing the concept of personalized lifelong learning pathways in a practical, user-friendly manner.



### **Alignment with LCAMP Objectives:**

The tool directly addresses several specific objectives of LCAMP WP5 and beyond. It provides the skills assessment toolkit (SO12) within an integrated platform, offers sector-specific datasets of trainings and micro-credentials linked to career pathways (SO13), and effectively leverages a clearing house for micro-credentials and training offers for the Advanced Manufacturing industry and its European Training Centres based on EU standards (SO14). It even contributes to SO15 by identifying needs for new micro-credentials for emerging skills. Furthermore, it supports the broader project goals of fostering a culture of excellence and lifelong learning in VET: by making skill gaps transparent and providing guidance to fill them, the tool helps learners and workers remain competitive and adaptable amid Industry 4.0/5.0 transformations. The tool also exemplifies the human-centric approach advocated by Industry 4.0, focusing on empowering individuals in their career development.

### **European Policy Context:**

Throughout its design, the tool was kept in sync with European frameworks and initiatives – it uses EQF for transparency of qualifications, ESCO for a common language on skills and occupations, and aligns with the European Digital Credentials (EDC) infrastructure and European Learning Model (ELM) for sharing learning achievement data. It effectively operationalizes the 2022 Council Recommendation on micro-credentials by integrating short learning offers into upskilling pathways. It also supports the goals of the European Skills Agenda and Osnabrück Declaration by providing a tool that helps make lifelong learning more accessible and demand-driven. By design, the platform can be connected to Europass or other EU tools, contributing to a cohesive European education and training digital ecosystem.

### **Outcomes and Impact:**

We anticipate several concrete outcomes from D5.4: (1) Individuals (students, job seekers, workers) will gain clearer insight into their skill profiles and receive actionable recommendations for further learning (micro-credentials, courses) to achieve their career goals – enabling efficient upskilling and reskilling. (2) Companies will be able to identify training needs of their staff more systematically and find relevant training opportunities to address those needs, thereby improving workforce competence and productivity. (3) VET institutions will benefit from data on skills demand and gaps to update curricula and offer new micro-credentials aligned with industry needs, as well as a modern tool to enhance student career services. (4) The collected database of job profiles and skills will serve as a resource for the LCAMP Skills Observatory (WP3) and for policymakers to understand advanced manufacturing skill needs across Europe. Thus, the tool not only serves immediate users but also feeds into strategic insights for training provision and policy.

### **Sustainability:**

A key aspect of concluding this deliverable is ensuring its sustainability beyond the project. As planned, the tool will be maintained under the auspices of the LCAMP Alliance of CoVEs. Partners have agreed on a maintenance plan (e.g., KIC and DHBW will provide technical hosting for at least 2 years post-project, and all partners will keep contributing updates to the job profiles and course database as Industry 4.0 evolves). The tool will become a standing feature of the LCAMP platform, which itself is intended to continue after project funding. There are also prospects to scale up: additional CoVEs or new sectors could be added (the model is extensible). We will explore integration with national systems – for example, some partners showed interest in linking the tool to their national qualification repositories or using it in Erasmus+ mobility projects to match learners to host company needs.



**Next Steps:** As we move forward, immediate next steps include:

- **Monitoring and Evaluation:** In the next 6-12 months, collect data on tool usage and outcomes. This will involve gathering user feedback, measuring how many suggested micro-credentials are actually taken up by users, and seeing if companies report improvements in addressing skill gaps. These findings will be reported in project evaluations and will help refine the tool if needed.
- **Promotion and Capacity Building:** Continue the dissemination efforts described (especially through 2026) to increase the user base. Additionally, conduct training-of-trainers sessions so that more VET counselors and HR professionals are comfortable integrating the tool into their practice.
- **Continuous Improvement:** Although D5.4 marks the deliverable, the development is inherently iterative. Based on user feedback and new requirements, we may implement enhancements. For instance, if many users request a feature to compare multiple job profiles side-by-side, we could add that. Or as new **Industry 5.0** roles emerge (e.g., roles related to AI ethics or sustainability in manufacturing), we will update the profile database to include them.
- **Linkage with Other Initiatives:** We plan to link the tool with the **European Digital Credentials for Learning** infrastructure – potentially enabling the tool to not just recommend micro-credentials but also help users receive them in digital format after completion. We will also watch for opportunities like the Europass platform’s planned features for career guidance and see if integration is beneficial.
- **Wider Rollout and Handover:** By the end of the project, we will package the tool and its content for handover to any interested stakeholder outside the consortium. That could mean making the code open source (if allowable), sharing the database (except personal user data) under an open license, and writing a “how-to-adopt” brief. This ensures the **transferability** of our outputs – so that other sectors or regions could replicate the approach, further amplifying impact.

In closing, Deliverable D5.4 has delivered an **innovative and timely solution** for bridging the skills gap in advanced manufacturing through lifelong learning pathways. It stands as a prime example of how EU-funded projects can produce practical tools that tie together education and industry needs. The collaboration of LCAMP partners – pooling expertise in VET, industry requirements, and digital credentialing – was instrumental in achieving this result. The tool’s future now depends on its continuous use and evolution, but given the strong foundation and positive reception so far, we are confident it will become a staple in advanced manufacturing skills development across our alliance and inspire similar approaches in other sectors. The next chapter will be written by the users themselves, as they navigate their careers with the help of this tool, and by the educators and policymakers who observe and support those journeys. LCAMP will remain engaged to ensure those next steps lead to enduring excellence in vocational education and training for advanced manufacturing, fully embracing the ethos of lifelong, life-wide learning in the era of Industry 5.0.



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Learner Centric Advanced Manufacturing Platform



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