HUCO LABS

Collaborative **H**VET-**U**niversity-**Co**mpany **Labs** for Research

Future Skills for Applied Innovation in Technical Professions -

The TRIComp Framework

(HUCO Labs – D2.1)

May 2025

Co-funded by
the European Union

Document History

Version	Date	Author	Reviewer	Description
1	05/02/2025	Jörn Allmang & Ulf-Daniel Ehlers		Initial document
2	11/02/2025	Jörn Allmang		Expansion to include competences from ITS Cuccovillo foundation curriculum
3	07/03/2025	Jörn Allmang	Ulf-Daniel Ehlers	Expansion to include competences from CMQ MSI
4	05/02/2025	Florian Linscheid, Ulf-Daniel Ehlers	Ulf-Daniel Ehlers	
5	22/05/2025	Florian Linscheid, Ulf-Daniel Ehlers	Ulf-Daniel Ehlers	Final Document
6	tbd	tbd	tbd	Project internal quality review
7	14/07/2025	Florian Linscheid	Ulf-Daniel Ehlers	Corrected version – visual error in graphic fixed (content unchanged)
7.1	16/07/2025	Florian Linscheid	Ulf-Daniel Ehlers	Corrected version – Table 13 title adjusted for clarity
8	21/08/2025	Florian Linscheid		Terminology change of competence domains All figures/tables relabeled to the new competence names; the original instrument with former labels is kept in Annex 9.3. Chapter 9.9 documents the renaming process and provides a transparent crosswalk between old and new labels.
8.1	29/09/2025	Florian Linscheid		EU logo updated: wording changed to "Co-funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Executive Summary

Context & Purpose

In the context of Europe's twin transition – digital and green – mid-level technicians are essential actors in driving innovation and implementing sustainable solutions. Yet, existing vocational education frameworks often do not fully capture these changing competence demands. This growing expectation requires vocational systems to anticipate change and provide a future-oriented learning environment.

The HUCO Labs project (Collaborative HVET-University-Company Labs for Research) addresses evolving competence needs among mid-level technicians in Europe. It supports the European Union's strategic priorities in innovation, digitalization, and sustainability by strengthening the interface between Higher Vocational Education and Training (HVET), universities, and companies.

Deliverable D2.1 presents the outcomes of WP2 Task 2.1 and introduces an empirically validated framework of Future Skills (FS) relevant to EQF levels 5 and 6. It is intended to guide Member States, training institutions, and industrial actors in adapting vocational curricula to support applied research, innovation, and cross-sectoral competence development.

Methodological Design

Combining analytical depth with practical validation, the framework was developed through a robust mixed-methods design involving evidence mapping, stakeholder input, and expert insight. It included:

- A Rapid Evidence Assessment (REA) of six EU and international competence frameworks (DigComp, GreenComp, AIComp, RECAPHE, NextSkills, EntreComp)
- A European-wide stakeholder survey with 150 responses from VET, applied R&D, and industry
- Twelve expert interviews conducted in five Member States

Initial mapping was based on five domains (Research, Development, Innovation, Green, and Digital). Based on observed overlaps and stakeholder input, these were consolidated into four strategic competence domains: **Innovation**, **Management**, **Green Transformation**, and **Digital**.

Key Findings

Building on the triangulated evidence base, the validated TRIComp Framework defines 22 Future Skills (FS-01 to FS-22), each empirically confirmed across stakeholder perspectives, educational models, and applied settings. They are grouped into four strategic domains: Innovation, Management, Green Transformation, and Digital.

Figure 1 provides an integrated visualisation of the TRIComp Framework, positioning the 22 Future Skills across four strategic competence domains. It serves as a conceptual anchor for vocational curriculum development at EQF levels 5 and 6.

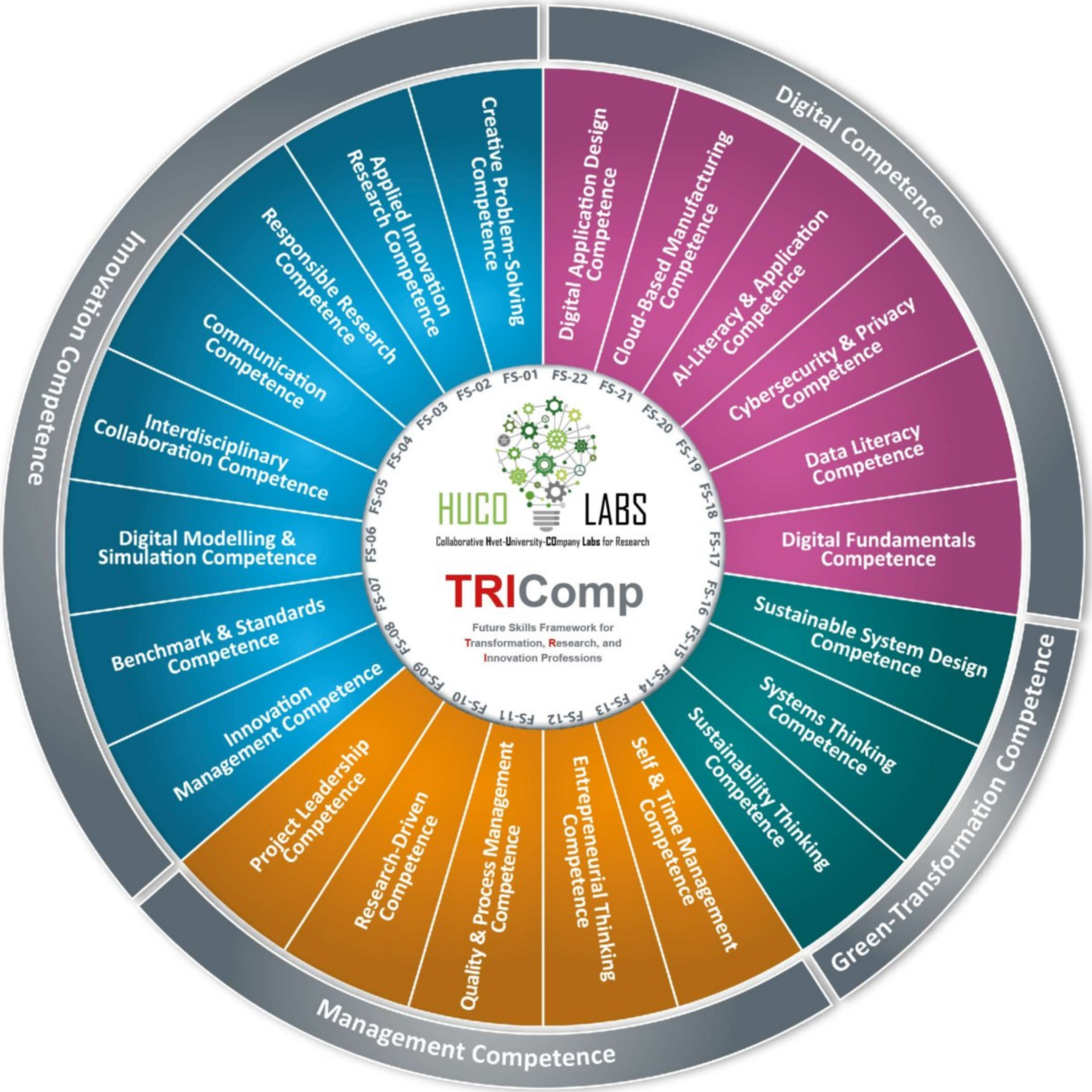

Figure 1: Transformation, Research, and Innovation Competences Framework (Executive Summary)

The TRIComp Framework reflects the real-world experiences of mid-level professionals in applied settings. It captures the demands they face – from agile development to sustainable systems thinking – and translates them into actionable competences.

Although FS-13 (Self & Time Management) was originally conceptualized in the NextSkills model, its critical relevance was reaffirmed through HUCO Labs data. Its cross-domain applicability warranted its recognition as a validated transversal competence within the TRIComp framework.

The **relevance matrix** shows that correlations between individual competences and their respective domain scores differ in strategic significance, reflecting the diverse functional roles of each skill. Sector-dependent nuances – particularly within the Innovation and Management domains –were observed. However, these variations did not reach statistical significance and should be interpreted as contextual variation rather than structural divergence.

For example, the Digital Transformation domain is presented in relevance matrix part D, which highlights the distribution of digital competences along relevance and strategic impact.

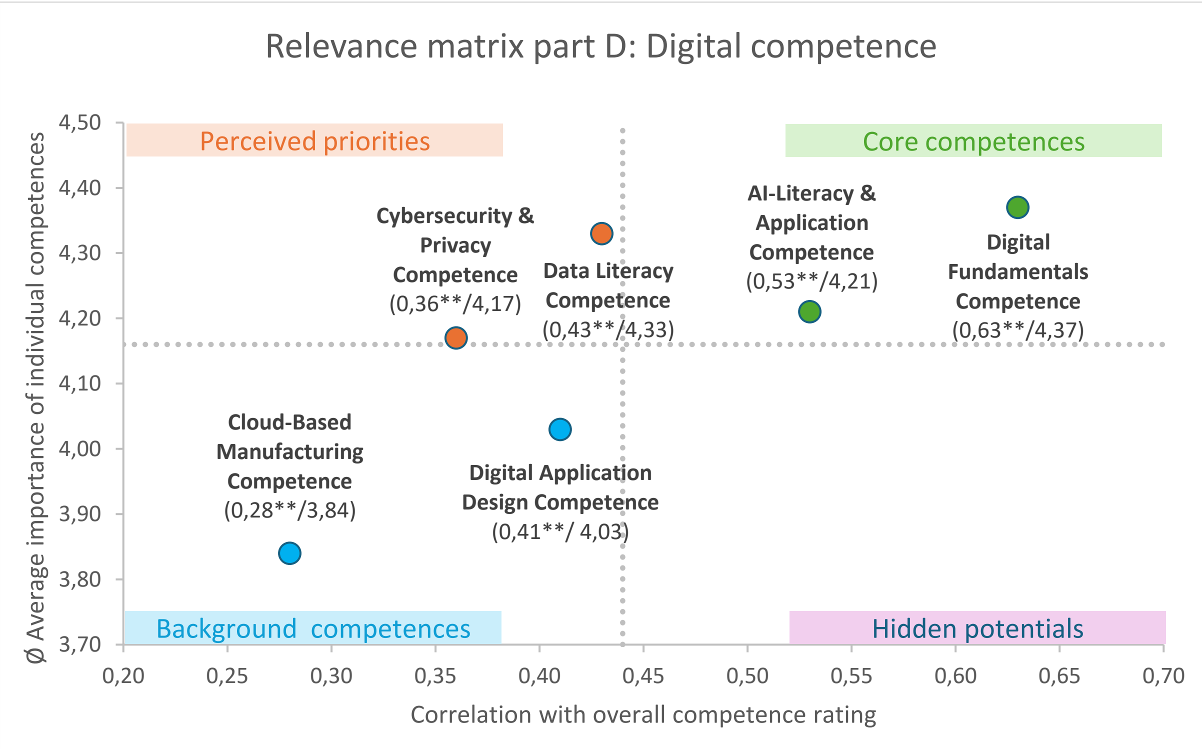

Figure 2: Relevance matrix digital competence (Part D; n=150) (Executive Summary)

Strategic Relevance

To meet rising expectations in times of rapid transformation, vocational systems must equip professionals with competences that anticipate future challenges and empower practitioners to deliver innovation aligned with Europe's twin transition goals. The TRIComp Framework contributes to key EU strategies such as the **European Skills Agenda**, the **Green Deal**, and the **Digital Education Action Plan**. It offers a modular, practice-oriented competence architecture for EQF levels 5 and 6 that can be flexibly integrated into national curricula and transnational training initiatives.

The framework addresses the evolving role of mid-level technicians as contributors to applied research and transformation, by supporting hybrid and interdisciplinary competence profiles. It enables targeted upskilling strategies, curriculum renewal, and policy alignment in vocational education.

Implications & Next Steps

The results of WP2 Task 2.1 provide a foundation for further pedagogical and structural innovation in vocational education. The framework may assist stakeholders in:

- Developing modular, competence-based curricula for EQF 5 and 6
- Integrating applied research skills into technical programs
- Strengthening interdisciplinary and work-based learning
- Supporting responsiveness to green and digital transition goals

The next phase will involve piloting the framework in selected HVET contexts and refining the descriptors based on feedback from educators, learners, and industry representatives.

As Europe redefines its skills agenda, the TRIComp Framework offers a strategic tool to design responsive curricula, inform upskilling programs, and foster resilient technical professions. Stakeholders across HVET, policy, and industry are invited to apply, adapt, and advance this model.

Key Takeaways

- 22 Future Skills (FS-01 to FS-22) form a validated competence framework, designed to be a basis for EQF levels 5 and 6 courses.
- The analysis showed that Self & Time Management Competence (FS-13) functions as a cross-domain core competence, confirming its transversal relevance across all strategic areas and aligning with EU-level frameworks.
- Mixed-methods triangulation ensured validity and contextual adaptability

- Individual competences vary in their correlation strength within domains; sector and size differences are minor and explainable
- The validated framework enables modular curriculum design and strategic competence development across national and transnational VET systems.
- It supports EU strategies including the Skills Agenda, the Green Deal, and the Digital Education Action Plan

Note on Terminology

Based on the results of the qualitative and quantitative survey, the competence names were revised. Throughout the entire project report, the updated competence names are applied to ensure logical consistency. For full transparency of the renaming process, Appendix 9.9 provides a 1:1 mapping table documenting the changes. The original questionnaire with the former competence labels is included in Section 9.3.

Table of Content

List of Figures

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

List of Tables

1 Introduction

1.1 Context and Purpose of the Report

The **HUCO Labs project** – **Collaborative HVET-University-Company Labs for Research** – aims to bridge the gap between Higher Vocational Education and Training (HVET), Universities, and Companies to foster innovation and research-driven competencies for mid-level technicians in the European labor market. In response to the evolving demands of Industry 4.0, digital transformation, and green economy initiatives, this report presents the results of **WP2 Task 2.1**, which focuses on identifying **key competencies for Future Skills** in technical professions.

The **primary goal** of this report is to systematically map and classify research, development, innovation, green transformation, and digital competencies within existing frameworks. This aligns with HUCO Labs' objective of establishing **a European platform for skills development** that enhances the permeability between HVET, universities, and industries while fostering **R&D-oriented skills at EQF levels 5 and 6**.

1.2 Research Rationale and Approach

The **increasing complexity** of industrial and technological environments demands that mid-level technicians not only acquire technical skills but also develop competencies in **research, innovation, and sustainability**. These competencies are crucial for ensuring effective participation in knowledge creation, incremental innovation, and the implementation of digital and green technologies. Recognizing these needs, HUCO Labs has undertaken **a structured investigation** to identify essential skills across four core domains:

1. **Innovation Competencies** – Encompass research literacy, creative problem-solving, interdisciplinary thinking, and the ability to generate new value through applied research and ideation processes.
2. **Green Transformation Competencies** – Cover sustainability assessment, circular economy strategies, and systems thinking for integrating environmental responsibility into industrial processes and product design.
3. **Digital Transformation Competencies** – Include digital literacy, cybersecurity, data analytics, artificial intelligence, and the ability to leverage digital tools for innovation, automation, and smart production.
4. **Management Competencies** – Integrate project coordination, entrepreneurial thinking, quality assurance, and the practical implementation of technical solutions within innovation and R&D contexts.

These domains reflect a consolidation of originally five areas.

To **ensure a rigorous and evidence-based** identification of these competencies, we employed the **Rapid Evidence Assessment (REA)** methodology. The REA provides a **systematic yet efficient** means of consolidating insights from existing research and competence frameworks, including **DigComp[1], GreenComp[2], AIComp[3], NextSkills[4], EntreComp[5], and RECAPHE[6]**.

1.2.1 Selection of Competence Frameworks

DigComp, GreenComp, AIComp, NextSkills, EntreComp, and RECAPHE

The selection of these six frameworks was a strategic decision grounded in their complementarity, European policy relevance, and suitability for EQF levels 5 and 6. Each framework contributes a distinct yet interlinked dimension to the overall competence landscape addressed in HUCO Labs. Their integration forms the foundation of the Future Skill Map presented in this report.

1.2.2 Complementarity of Frameworks

Each selected framework represents a vital competence domain required for future-oriented research, innovation, and development in technical professions. An overview of these frameworks and their specific contributions to the HUCO Future Skills model is provided in Table 1.

Table 1: Overview of Reference Frameworks and Their Conceptual Contribution

Framework	Primary Focus Area	Contribution to HUCO Future Skills Framework
DigComp	Digital competencies	Digital literacy, cybersecurity, data competence
GreenComp	Sustainability and environmental transformation	Systems thinking, circular economy, sustainable design

[1] Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The digital competence framework for citizens – With new examples of knowledge, skills and attitudes. Joint Research Centre. https://data.europa.eu/doi/10.2760/115376.

[2] Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). GreenComp: The European sustainability competence framework. Joint Research Centre. https://data.europa.eu/doi/10.2760/13286.

[3] AIComp Consortium (2023). *AI Competence Framework*. Internal project report. Not publicly available.

[4] Ehlers, U.-D. (2020). *Future Skills – The Future of Learning and Higher Education*. Springer. https://doi. org/10.1007/978-3-658-29297-3.

[5] Bacigalupo, M. et al. (2016). *EntreComp: The Entrepreneurship Competence Framework*. JRC. https://doi. org/10.2791/593884.

[6] Rodrigues, M., & Brunner, M. (Eds.). (2020). Competence framework for applied research in universities of applied sciences. RECAPHE Project. https://recaphe.eu/project-outputs/

Framework	Primary Focus Area	Contribution to HUCO Future Skills Framework
AIComp	Artificial intelligence and automation	AI ethics, simulation, AI integration in industry
NextSkills	Transversal future skills & self-organization	Self-directed learning, adaptability, future-readiness
EntreComp	Entrepreneurial thinking & innovation competence	Ideation, value creation, initiative, opportunity recognition
RECAPHE	Applied research in higher education	Design research, ethical research, academic-industry communication

Together, these frameworks span all skill domains critical to empowering mid-level technicians to support Europe's green and digital transitions.

1.2.3 Alignment with EU Policies

All selected frameworks are either developed or endorsed by European institutions and support the strategic goals of:

- The **European Skills Agenda**[7]
- The **European Green Deal**[8]
- The **Digital Education Action Plan**[9]
- The **New European Innovation Agenda**[10]

This ensures that the HUCO Labs competence framework is fully aligned with current EU policy priorities and contributes to broader workforce transformation efforts.

1.2.4 Applicability to EQF Levels 5–6

Each framework provides competence descriptors that are directly applicable to the skill levels, responsibilities, and work contexts of mid-level technicians. This makes them highly usable for designing curricula and work-based learning strategies that bridge the domains of HVET, applied research, and industrial innovation.

[7] European Commission (2020). *European Skills Agenda for sustainable competitiveness, social fairness and resilience.* https://ec.europa.eu/social/main.jsp?catId=1223.
[8] European Commission (2019). *The European Green Deal.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640.
[9] European Commission (2020). *Digital Education Action Plan 2021–2027.* https://education.ec.europa.eu/focus-topics/digital/digital-education-action-plan.
[10] European Commission (2022). *A New European Innovation Agenda.* https://ec.europa.eu/info/research-and-innovation/strategy/support-policy/new-european-innovation-agenda_en.

1.2.5 Selection Criteria via Rapid Evidence Assessment

The selection was the result of a structured **Rapid Evidence Assessment (REA)** process, guided by the following criteria:

- Relevance to research, innovation, digitalization, sustainability
- Recency (frameworks published between 2018 and 2024)
- Practical usability for competence-based education and upskilling

Among the many existing frameworks, these six emerged as the most relevant, comprehensive, and actionable sources for developing a forward-looking competence map.

1.2.6 Validation by Stakeholder Data

Beyond desk research, the framework selection was enriched and validated through:

- A **quantitative survey** with 169 participants. **150 of whom were based in Europe**[11]
- **12 expert interviews** with stakeholders from industry, HVET, and applied R&D across five countries

This triangulation ensured that the frameworks reflect not only policy and research priorities, but also real-world needs in advanced manufacturing.

1.2.7 Synthesis and Conclusion

The selection of DigComp, GreenComp, AIComp, NextSkills, EntreComp, and RECAPHE ensures:

- Comprehensive coverage of all key future skill domains
- Consistency with EU-level policies and educational strategies
- Relevance for mid-level professionals at EQF levels 5 and 6
- High complementarity and coherence within the HUCO Labs Future Skill Map
- Validation through stakeholder feedback and empirical analysis

Together, they provide a robust foundation for developing competence-based training, facilitating research-based learning, and promoting innovation-driven workforce resilience.

[11] A total of 169 completed responses were collected. For the main statistical analyses, a subset of 150 respondents from European countries was used to ensure policy relevance and consistency.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

1.3 Key Contributions of WP2 Task 2.1

The **competence identification process** followed a structured methodology that included:

- **A comprehensive literature review** of existing competence models.
- **Mapping of competencies to existing frameworks** to ensure alignment with European skills policies.
- **Validation through expert consultation** to assess relevance and applicability in real-world industrial and academic settings.

As a result, the report provides a consolidated list of competencies categorized into the four identified skill domains: Innovation, Green Transformation, Digital, and Management[12]. These competencies are further **mapped to the NextSkills Competence Model**, ensuring their integration into broader future skills frameworks.

1.4 Structure of the Report

The report is structured as follows:

- **Definitions of Future Skills in Technical Professions** – Establishing key terminologies and competency descriptions.
- **Research Methodology: Rapid Evidence Assessment (REA)** – Detailing the methodological approach, selection criteria, and categorization process.
- **Competence Identification and Categorization** – Presenting the extracted competencies across four integrated domains: innovation, green transformation, digital, and management.

  The original categories of research and development have been merged into these broader competence areas in line with real-world application and empirical validation.
- **Mapping to the NextSkills Model** – Aligning identified competencies with broader European competency frameworks.
- **Clustered Competencies According to the Next Skills Competence Model** – Providing a structured classification based on emerging professional demands.

[12] These domains result from the empirical consolidation of an initial five-domain structure (Research, Development, Innovation, Green, Digital), as explained in Section 2.1.1.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

1.5 Impact and Next Steps

By identifying and structuring these competencies, **WP2 Task 2.1 lays the foundation for designing new HVET training pathways** that integrate R&D-related skills into **EQF level 5 and 6 curricula**. This will enable mid-level technicians to participate more effectively in **research and innovation activities**, contributing to **Europe's technological and economic competitiveness**.

The findings of this report will serve as a **basis for the development of new teaching methodologies, curriculum design, and training models** in subsequent work packages of the HUCO Labs project. The next steps include **testing these competencies in pilot HVET programs** and refining them through industry feedback to ensure maximum relevance and applicability.

Through this initiative, HUCO Labs aims to create a **sustainable and scalable training ecosystem** that enhances the integration of **research, digital transformation, and sustainability skills** into the technical workforce across Europe.

1.6 Summary

This chapter defined the purpose, theoretical foundation, and methodological framing of the HUCO Labs Future Skills Report. It introduced the competence domains, outlined the framework selection process, and positioned the report within EU policy goals and HVET development.

Chapter 2 provides the theoretical definitions and core concepts that frame the competence understanding used throughout the report. The next chapters detail the methodological design (Chapter 3), empirical validation (Chapter 4), and the development of the integrated Future Skills framework (Chapter 5).

2 Theoretical Framework and Definitions

2.1 The Concept of Future Skills in the Context of Research and Development

The rapid transformations in technology, sustainability, and the economy demand a shift in how we define and cultivate professional competencies. Future Skills, a concept increasingly central to education, workforce development, and research, refer to the ability of individuals to navigate complex, uncertain, and dynamic environments successfully. Drawing on years of empirical work in the field of higher education (Ehlers, 2020; Ehlers & Eigbrecht, 2024), the Future Skills approach emphasizes that these competencies extend beyond technical knowledge, incorporating adaptability, critical thinking, and interdisciplinary collaboration to address global challenges.

HUCO Labs' research aims to identify and classify Future Skills relevant to research, development, innovation, green transformation, and digital transformation. By systematically mapping existing competence frameworks, this study provides an empirical foundation for competence development in these areas. The concept of Future Skills serves as a guiding principle for our investigation, helping to structure competencies that are crucial for the future of work and education.

Building on this broad conceptualization, the HUCO Labs framework specifically emphasizes the role of Future Skills within Research and Development (R&D).

The rapid transformation of industrial and technological environments requires new, future-oriented competencies that go beyond traditional technical knowledge. In the context of R&D, Future Skills encompass the ability to act autonomously, creatively, and collaboratively in complex and dynamic settings. They combine technical expertise with the capability to innovate, integrate sustainability goals, and leverage digital technologies for enhanced problem-solving and value creation.

This integrated conceptual foundation forms the basis for the subsequent development of the HUCO Labs Future Skills Framework.

2.2 Definition of Future Skills in the HUCO Context

In the HUCO Labs framework, Future Skills are defined as the set of competencies that enable mid-level technicians to successfully navigate and shape the intersection of research, innovation, and design processes within advanced manufacturing industries. These skills integrate domain-specific expertise, transferable soft skills, and value-driven decision-making capacities to support technological, sustainable, and digital transformations in the workplace. They are rooted in competence-based learning theories and draw upon interdisciplinary action competence models.

The HUCO Labs Future Skills concept builds on a broader understanding of future-oriented competencies, as outlined in contemporary educational research and competence frameworks. In the following sections, we present both a general definition of Future Skills and the theoretical foundations underlying this concept.

A) Conceptual Model and Definition of Future Skills

Future Skills are **dispositions for action** that enable individuals to respond effectively to highly dynamic and complex professional environments (Ehlers, 2020). Unlike traditional skills, which focus on the accumulation of domain-specific knowledge, Future Skills emphasize **self-organization, adaptability, and value-based action**. These competencies integrate **cognitive, motivational, and social resources**, enabling individuals to act effectively in unpredictable settings.

Future Skills unfold through the **interplay of two core dimensions**:

1. Capacity to act, grounded in knowledge and skills;
2. Disposition to act, shaped by values and attitudes.

Both dimensions must be present and integrated to form a full competence. Only when individuals possess not only the cognitive and practical ability, but also the inner orientation to act responsibly and autonomously, can Future Skills be realized as actual performance in complex contexts (Ehlers, 2020; Ehlers & Eigbrecht, 2024).

For the purpose of this study, we define **Future Skills** as:

> "Competences that enable individuals to act successfully in complex, rapidly changing environments by integrating domain knowledge, transferable skills, and value-driven decision-making" (Ehlers, 2020).

This approach aligns with **competence-based learning theories**, which highlight the role of knowledge, skills, and attitudes (KSA) as **essential components of competence development** (Mulder & Winterton, 2017). Future Skills are neither static nor merely acquired through instruction; they evolve through active learning, engagement in real-world challenges, and interdisciplinary practice.

The conceptual structure of Future Skills is illustrated in Figure 3, highlighting the interrelation between knowledge, skills, values, and attitudes as the foundation for action readiness and competence performance in complex, dynamic environments

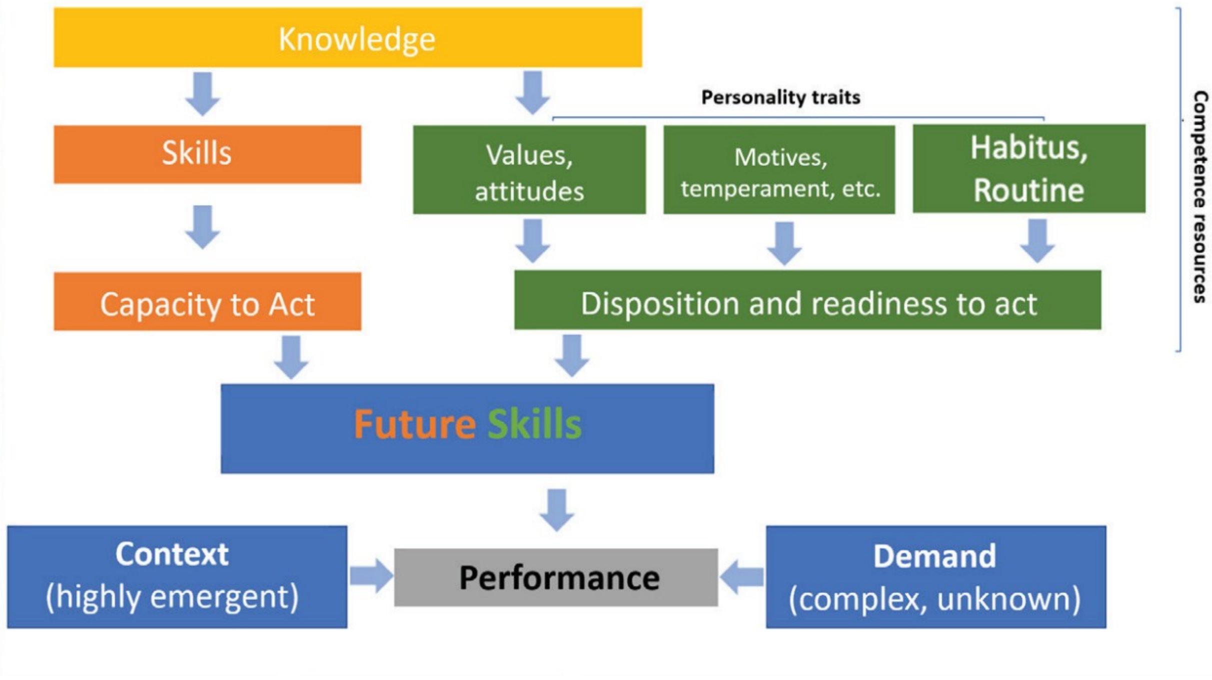

Figure 3: Competence Structure Model for Future Skills (Ehlers 2020)

B) Theoretical Foundations

The theoretical foundations of Future Skills research build upon **subject-centered and action-oriented learning theories**. These perspectives emphasize the learner as an active agent who develops competencies through practice and reflection in real-world contexts.

Action Competence and Habitus Theory (Bourdieu, 1986)

Bourdieu's theory of habitus highlights how competencies are internalized through experience and socialization, shaping individuals' structured dispositions to act. Competence development is thus not simply knowledge acquisition but the formation of an action-oriented mindset aligned with professional and cultural contexts.

Self-Organization and Agency (Erpenbeck & Heyse, 2007; Erpenbeck & Sauter, 2015; Cinner & Barnes, 2019)

The concept of self-organization as a foundational mechanism of competence development was first conceptualized by Erpenbeck and Heyse (2007) as the ability to act autonomously in complex, dynamic environments. Building on this theoretical foundation, Erpenbeck and Sauter (2015) emphasize that individuals develop competencies by integrating cognitive, emotional, and motivational resources into reflective, value-based actions.

This understanding closely aligns with Cinner and Barnes's (2019) conceptualization of agency as a key dimension of social resilience: the power and freedom to mobilize one's assets, flexibility, learning, and socio-cognitive capacities to actively shape the future.

Agency, as they define it, reflects people's belief in their own ability to manage prospective situations and control events that affect them. It encompasses self-efficacy and empowerment, and crucially distinguishes voluntary from forced adaptation in response to social-ecological change.

Both perspectives emphasize that adaptive competence is not a passive outcome of resources or knowledge, but arises from the capacity to engage in purposeful, self-directed, and socially embedded action under uncertainty.

Future Skills as Transversal Competencies (Ehlers, 2020)

Future Skills research emphasizes the importance of transversal competencies that apply across various fields and professions. Critical thinking, interdisciplinary collaboration, and complex problem-solving are increasingly seen as fundamental capabilities necessary for success in research, development, innovation, digitalization, and sustainability-driven transformation.

These theoretical foundations highlight that Future Skills must be understood as dynamic, evolving capacities that enable individuals to act effectively in diverse, complex, and rapidly changing environments – a core premise underpinning the HUCO Labs approach to competence development.

Building upon these theoretical foundations and definitions, the HUCO Labs project has identified five key competence domains that are central to the development of Future Skills for mid-level technicians in research, development, innovation, green transformation, and digital transformation.

Research Skills – Enabling professionals to investigate, analyze, and generate knowledge through scientific inquiry and evidence-based decision-making.

Development Skills – Supporting the design, implementation, and improvement of products, systems, and technical solutions.

Innovation Skills – Fostering creativity, entrepreneurship, and novel approaches to problem-solving in dynamic contexts.

Green Transformation Skills – Equipping individuals with the knowledge and strategies to integrate sustainability and circular economy principles into their work.

Digital Transformation Skills – Preparing professionals to navigate and leverage emerging digital technologies, artificial intelligence, and data analytics for enhanced productivity.

Each of these domains reflects a competence-based approach, integrating knowledge (what individuals know), skills (what they can do), and attitudes (how they approach challenges and adapt to change).

Future Skills research thus provides a systematic framework for understanding and developing professional competencies in an era of rapid technological and societal change. By focusing on self-organization, adaptability, and cross-disciplinary expertise, Future Skills redefine the way individuals prepare for and engage in professional practice.

The HUCO Labs study contributes to this growing field by mapping existing competence frameworks to identify the most relevant competencies in research, development, innovation, sustainability, and digital transformation. Through this approach, we aim to support the integration of competence-based learning in higher education, workforce development, and professional training.

C) Rationale for the Final Four Competence Domains

The HUCO Labs Future Skills Framework is structured around four strategic competence domains: Innovation, Green Transformation, Digital, and Management. This configuration results from a structured synthesis of theoretical models and practical requirements derived from vocational contexts.

The definition of the four final competence domains is based on a synthesis of theoretical frameworks and vocational requirements. Their evolution is outlined in the following section.

D) From Five to Four: The Evolution of the Domain Architecture

To reduce conceptual redundancy and better reflect the operational logic of applied industrial practice, these five domains were consolidated into four functional clusters:

1. Innovation (including applied research, creativity, and interdisciplinary thinking),
2. Green Transformation
3. Digital, and
4. Management (including development coordination, project and quality management, and entrepreneurship).

The decision to consolidate the domains reflects the recognition that research is a cross-cutting element present in all competence areas, rather than a standalone domain. To illustrate the conceptual evolution. Table 2 maps the initial five-domain structure onto the consolidated four-domain architecture that underpins the TRIComp Framework.

Table 2: Domain Consolidation from Version 1 to Version 2

Original Domain Structure	Consolidated Final Domains
Research	
Development	Management
Innovation	Innovation
Green Transformation	Green Transformation

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Original Domain Structure	Consolidated Final Domains
Digital Transformation	Digital

E) Educational Foundation: Competence-Based and Future-Oriented

The domain structure, as illustrated in Figure 1, reflects a competence-based understanding of learning and development, aligned with established educational theories:

- **Knowledge**: Technical, theoretical, and contextual understanding
- **Skills**: The ability to apply knowledge in diverse, real-world situations
- **Attitudes**: Motivation, responsibility, adaptability, and value-driven action

This tripartite model is rooted in action competence theory, self-organization models, and the definition of **Future Skills as action dispositions** (Ehlers, 2020). It ensures that the framework not only defines what learners must know, but also what they must be able to do – and how they must approach their role in future work environments.

F) Functional Validity: Reflecting Real-World Roles of Mid-Level Technicians

Each of the four final domains maps directly to the actual responsibilities, tasks, and transformation challenges faced by EQF level 5–6 professionals. Table 3 maps the four final domains to their respective focus areas, reflecting their practical relevance for EQF 5–6 roles.

Table 3: Overview of Integrated Focus Areas Across Final Competence Domains

Final Domain	Integrated Focus Areas
Innovation	Research application, creativity, problem-solving, interdisciplinary collaboration
Green Transformation	Sustainability integration, systems thinking, ecological design
Digital Transformation	Data competence, cybersecurity, AI, cloud platforms
Management	Project coordination, quality assurance, entrepreneurial skills

G) Strategic Alignment: Supporting the Twin Transition

The competence domains defined in the HUCO Labs framework were designed to align with the European Union's strategic agenda for the **Twin Transition** – the simultaneous green and digital transformation of the economy and society. In addition, two transversal focus areas were integrated that are considered essential enablers for the successful implementation of this transformation:

- **Green Transition**: Circular economy, life-cycle thinking, sustainable systems design
- **Digital Transition**: Data-driven innovation, AI readiness, integration into digital ecosystems
- **Innovation-Based Competitiveness**: Creative agility, applied research, strategic value creation
- **Workforce Resilience**: Lifelong learning, hybrid skill profiles, professional adaptability

By aligning its competence structure with these strategic EU priorities, the HUCO Labs framework ensures **future relevance**, **policy coherence**, and practical utility in supporting mid-level professionals in the context of Europe's industrial and educational transformation.

H) Empirical Triangulation: A Mixed-Methods Foundation

The final domain structure was derived through **empirical triangulation**, integrating three sources of evidence:

- **Desk research**: Analysis of over a dozen European competence frameworks
- **Quantitative survey**: 150 stakeholders from Europe
- **Qualitative interviews**: Experts from industry, HVET, applied R&D

This approach ensured both top-down conceptual grounding and bottom-up practical validation. Across all data sources, the identified skills consistently clustered into the four final domains.

I) Practical Utility: A Framework for Curricula and Upskilling

The selected domains are:

- **Comprehensive: Covering all future-oriented capability fields relevant to technical professions**
- **Modular: Allowing flexible curriculum design across national and sectoral contexts**
- **Operationalizable: Directly translatable into learning outcomes, competence descriptors, and training modules**

This ensures that the HUCO Labs Future Skills Framework can be effectively applied by educators, trainers, and policymakers alike.

Summary

The final competence framework of the HUCO Labs project comprises **four interrelated domains**:

- **Innovation**
- **Green Transformation**
- **Digital Transformation**
- **Management**

These domains:

- Evolved from an original five-domain model through empirical validation,
- Reflect the real functional areas of mid-level technical roles,
- Align with European policy strategies and innovation trajectories,
- Support the integration of research, sustainability, and digitalization into vocational learning.

The result is a **future-proof, evidence-based, and application-oriented competence structure** that supports the European workforce in mastering the demands of the twin transition and beyond.

The integration of Research and Development across all domains reflects the recognition that research is not a standalone competence area, but a transversal capability embedded throughout the entire TRIComp Framework. These theoretical foundations and structural definitions provide the conceptual groundwork for the competence mapping and target group specification in the following sections.

2.3 Description of the Target Group: Mid-Level Technicians (EQF Levels 5 and 6) in Advanced Manufacturing

The HUCO Labs project focuses on mid-level technical professionals positioned at EQF Levels 5 and 6, who serve as key operational and innovation actors in advanced manufacturing environments. These professionals implement innovative technical solutions, optimize production systems, contribute to applied research, and actively facilitate digital and green transitions within industrial ecosystems.

To meet these complex and interdisciplinary demands, they require a robust foundation in applied technical skills, systems thinking, research methods, and cross-functional collaboration. Their ability to bridge strategic development and hands-on execution makes them indispensable for translating innovation into sustainable, competitive industrial practices across Europe.

A more detailed illustration of typical technician profiles and their developmental trajectories is provided later in Chapter 5.2, where personas serve to exemplify the applied relevance of the developed TRIComp Framework.

2.4 Summary

By aligning with European strategic priorities such as the Twin Transition, lifelong learning, and workforce resilience, the framework ensures both practical relevance and policy coherence.

By synthesizing empirical evidence with conceptual models, the TRIComp Framework offers a future-ready competence structure that not only reflects current demands but anticipates the evolving landscape of applied innovation, sustainability, and digitalization in vocational education.

The definitions and domain architecture presented here will be translated into measurable competences and validated through mixed-methods research in the following chapters.

3 Research Design for Future Skills Framework Development

The HUCO Labs Competence Report aims to systematically identify and analyze existing competence frameworks. These were initially clustered into five domains: research skills, development skills, innovation skills, green transformation skills, and digital skills.

During the empirical refinement phase, these domains were consolidated into four strategic areas: **Innovation**, **Green Transformation**, **Digital Transformation**, and **Management** (see Section 2.1.1).

This consolidation addressed thematic overlaps, especially between research and innovation, as well as development and management competencies.

The guiding research question was initially:

"Which research skills, development skills, innovation skills, green transformation skills, and digital skills are currently recognized in established competence frameworks?"

Following consolidation, the refined research question became:

"Which strategic competences are essential for mid-level technicians to drive innovation, sustainability, digitalization, and management in advanced manufacturing?"

The research process was based on a **Rapid Evidence Assessment (REA)**, a structured review method that applies systematic principles while allowing for pragmatic trade-offs in scope and depth. This approach was selected for its ability to efficiently synthesize existing knowledge and provide timely, actionable insights.

Our study followed a **mixed-methods approach**, integrating:

- **Desk research**: A comprehensive literature review of competence models across the five identified domains.
- **Expert consultation**: Semi-structured interviews with domain experts to validate findings and ensure completeness.
- **Competence mapping**: A systematic extraction and categorization of relevant competencies from identified frameworks.
- **Quantitative analysis**: Statistical evaluation of identified competence items to detect patterns and gaps.

3.1 Desk Research Design and Conceptual Basis

3.1.1 Methodology: Rapid Evidence Assessment (REA)

The desk research phase was conducted using a structured Rapid Evidence Assessment (REA) methodology to systematically synthesize existing competence frameworks and scientific studies.

The REA process was adapted to fit the specific objectives of the HUCO Labs project and was carried out in twelve steps:[13].

Table 4 presents the HUCO Labs adaptation of the REA method, showing how each step was customized to the project's objectives.

Table 4: HUCO Labs Adaptation of the Rapid Evidence Assessment (REA)

Step	REA Description	HUCO Labs Adaptation
1. Background	Defines the study context.	Identification of research, development, innovation, green transformation, and digital competencies.
2. Research Question	Specifies study objectives.	What are the key competencies in these domains across existing frameworks?
3. Inclusion Criteria	Determines relevant studies.	Focus on frameworks published between 2018-2024, in English or German, covering competence models.
4. Search Strategy	Identifies sources.	Multi-dimensional search: academic databases, EU competence reports, industry white papers, organizational frameworks.
5. Study Selection	Filters studies based on abstracts and relevance.	Priority given to frameworks with structured competence definitions and practical applications.
6. Data Extraction	Extracts relevant competence items.	Competence items mapped to five core categories based on definitions and key components.
7. Critical Evaluation	Assesses quality and consistency.	Items reviewed for clarity, specificity, and practical applicability.
8. Results Consolidation	Synthesizes findings.	Competences structured into a consolidated framework.

[13] The Rapid Evidence Assessment (REA) is a streamlined form of systematic literature review used in applied policy contexts. It balances methodological rigor with feasibility by employing transparent, structured review processes within time-limited constraints. For methodological grounding, see: Thomas, J. & Newman, M. (2005). *Rapid Evidence Assessments of research to inform social policy: Taking stock and moving forward.* London: EPPI-Centre, University of London. Available at: https://eppi.ioe.ac.uk/cms/Default.aspx?tabid=64

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Step	REA Description	HUCO Labs Adaptation
9. Competence Mapping	Organizes competencies into domains.	Cross-referencing of identified competencies with existing classification models.
10. Conclusion	Identifies gaps and patterns.	Formulation of a structured competence taxonomy.
11. Limitations	Describes methodological constraints.	Potential gaps in sector-specific competencies noted.
12. Practical Implications	Suggests applications.	Recommendations for education, training, and workforce development.

3.1.2 Capitalized Frameworks and Literature Sources

The desk research phase applied a structured Rapid Evidence Assessment (REA) to identify a preliminary set of R&D-related competences from existing European frameworks.
These findings formed the **analytical foundation for the survey design** (quantitative validation) and **guided the interview protocol** (qualitative exploration), ensuring that the empirical investigations build directly upon state-of-the-art competence models.

In developing the HUCO Labs Future Skills Framework, the project team actively capitalized on the findings, methodologies, and conceptual models of previously funded European research and development initiatives. This approach ensured conceptual continuity, avoided duplication of efforts, and aligned HUCO Labs with established good practices in competence-based education and training.

The following projects and frameworks were systematically reviewed and integrated where relevant:

- **Future Skills Research (NextEducation, DHBW)**
  Source: Ehlers, U.-D. (2020). *Future Skills – The Future of Learning and Higher Education*. Springer.
  Link: https://link.springer.com/book/10.1007/978-3-658-29297-3
  Contribution: Conceptual model of Future Skills as action dispositions; structuring of transversal competence domains (e.g., creativity, adaptability, self-organization).
- **RECAPHE – Research and Innovation Competences for Professional Higher Education**
  Source: https://www.recaphe.eu
  Contribution: Framework for applied research competencies in universities of applied sciences (e.g., design research, ethical research, academic-industry collaboration).

- **AIComp – Artificial Intelligence Competence Framework**
  Contribution: Competence descriptors for AI readiness, simulation, ethical AI use, and cross-sector AI applications in technical contexts.
- **GreenComp – European Sustainability Competence Framework**
  Source: Bianchi, G. et al. (2022). *GreenComp: The European Sustainability Competence Framework*. JRC Science for Policy Report. European Commission.
  Link: https://publications.jrc.ec.europa.eu/repository/handle/JRC128040
  Contribution: Detailed descriptors of sustainability competences such as systems thinking, sustainable development, and circular economy strategies.
- **DigComp 2.2 – Digital Competence Framework for Citizens**
  Source: Vuorikari, R. et al. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens*. JRC Publications.
  Link: https://data.europa.eu/doi/10.2760/115376
  Contribution: Structured taxonomy of digital skills (e.g., data competence, cybersecurity, digital content creation).
- **EntreComp – The Entrepreneurship Competence Framework**
  Source: European Commission (2016). *EntreComp: The Entrepreneurship Competence Framework*.
  Link: https://ec.europa.eu/social/main.jsp?catId=1317&langId=en
  Contribution: Core entrepreneurship skills such as initiative, value creation, risk assessment, and innovation management.
- **GIENAHS (Erasmus+ Project)**
  Source: https://gienahs.eu
  Contribution: Guidelines for integrating applied research in HVET; definition of innovation-enabling environments for mid-level technicians.
- **ENHANCE Alliance (UPV)**
  Contribution: Methodological insights into European competence integration and digital transformation within higher education institutions.
- **DIRK Dual & Deal with Digital Work-Based Learning (DHBW)**
  Contribution: Best practices in dual higher education and digitally supported work-based learning. Provided foundations for designing applied learning contexts and competence assessment tools.

3.1.3 Consolidated Competence Domains and Survey Logic

To ensure methodological coherence between the conceptual framework and the empirical instruments, the four-domain model introduced in Section 2.1.2 was systematically translated into the HUCO Labs survey design. Each domain was represented by a dedicated cluster of Future Skills (FS-01 to FS-21[14]), structured into four parts (A–D).

The following table presents an overview of how the consolidated competence domains were mapped within the survey instrument, along with key source frameworks for each domain:

Table 5 Consolidated Future Skill Domains as Applied in the HUCO Labs Survey Instrument

Survey Part	Domain	Future Skills	Key Sources
Part A	Innovation Competences	FS-01 to FS-08	RECAPHE, NextSkills, Cuccovillo Foundation Curriculum
Part B	Management Competences	FS-09 to FS-12	RECAPHE, NextSkills, UniWiND
Part C	Green Transformation Competences	FS-13 to FS-15	GreenComp, RECAPHE
Part D	Digital Competences	FS-16 to FS-21	DigComp, AIComp, Cuccovillo Foundation Curriculum

Transversal competences – such as *interdisciplinary collaboration, systemic innovation,* and *professional communication* – were embedded across Parts A and B, drawing particularly on **NextSkills** and **EntreComp**.

To ensure traceability and analytical clarity throughout the validation phases, each competence was assigned a unique identifier (FS-XX). This allowed for systematic referencing during both the quantitative analysis (see Chapter 4.2) and the qualitative interpretation (see Chapter 4.3), while maintaining structural consistency at the domain level.

By aligning the conceptual taxonomy with the survey structure, the HUCO Labs framework ensured:

- Strategic alignment with European policy initiatives (e.g., European Skills Agenda, Twin Transition),
- Operational readiness for competence mapping and statistical validation,
- Compatibility with existing frameworks in vocational and higher education across Europe.

[14] Following the qualitative analysis (see Chapter 4.3), an additional competence was integrated into the framework, bringing the total number of Future Skills to 22.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

3.2 Survey Design and Implementation

To empirically validate and prioritize the competence domains identified through desk research, an online survey was conducted among European stakeholders from vocational education, applied research, and industry.

3.2.1 Survey Design and Implementation

The online questionnaire was developed in English and disseminated across five European partner countries (Germany, Italy, France, Spain, and Lithuania). Given the expected case numbers per country (typically below 50), a single-language format was chosen to ensure consistency, minimize translation-related complexity, and streamline data processing.

The survey campaign was officially launched on **03 March 2025**, with a targeted data collection period ending on **31 March 2025**. The relatively short field phase required coordinated efforts by all partners. Each consortium partner was asked to secure **between 20 and 40 completed responses per country**, aiming for a **minimum of 100 and an ideal of 250 full completions** overall.

To support participation, a dedicated Q&A session was offered to address any methodological or technical concerns. Partners were encouraged to reach out proactively in case of barriers to achieving their response targets, so that joint mitigation strategies could be developed.

The survey design reflects the original domain architecture (Version 1). Subsequent data analysis (Chapter 4) was structured according to the consolidated four-domain model.

3.2.2 Survey Structure

The questionnaire was implemented using the Customer Quest survey platform and consisted of three main sections:

- **Competence Assessment**: Respondents were asked to evaluate the importance of 25 competence items across four strategic domains (Innovation, Management, Green Transformation, Digital). Each competence was rated twice – first for **current relevance** and then for **anticipated relevance in five years**. A **five-point Likert scale** was used (1 = "Not important", 2 = "Slightly important", 3 = "Moderately important", 4 = "Important", 5 = "Very important"). An additional response option **"I don’t know"** was included separately and later coded as a missing value (999) for statistical analysis.

- **Open Input Fields**: Participants had the opportunity to suggest **additional competences** they considered relevant for future-oriented technician profiles. This section helped capture emerging trends beyond the predefined framework.
- **Descriptive Data Collection**: Sociodemographic and contextual information (e.g., country, professional role, sector, number of employed technicians, qualification level) was gathered to allow subgroup analyses and stratified interpretation.

The collected data were **numerically coded** and processed using **SPSS (Statistical Package for the Social Sciences)**. The Likert responses were assigned values from 1 to 5; "I don't know" responses were coded as 999. The SPSS analysis generated **relevance-priority matrices** for each domain and competence item, enabling a comparative visualization of **current vs. future relevance** and identification of **strategic competence gaps** (see Chapter 5.1).

These results directly informed the refinement of the HUCO Future Skills Framework and served as the quantitative foundation for triangulation with the qualitative interview findings.

3.2.3 Data Preparation and Analysis

Prior to statistical evaluation, all survey data underwent a structured preparation process. Responses were exported from the **Customer Quest** platform and systematically reviewed for completeness, plausibility, and consistency. **Only fully completed questionnaires were included** in the final dataset – i.e., only those in which all competence items had been rated. This strict inclusion criterion was applied to ensure full comparability and statistical reliability in the matrix-based analyses.

The five-point Likert scale responses were numerically coded as follows:

1 = Not important, 2 = Slightly important, 3 = Moderately important, 4 = Important, 5 = Very important.

The additional option **"I don’t know"** was treated as a separate category and coded as **999** in SPSS (system missing).

Descriptive statistics (mean, standard deviation) were calculated for each item. Based on these data, **relevance-priority matrices** were generated for each domain. These visualizations highlighted competences with particularly high expected growth in importance or significant future potential.

Furthermore, **correlation analyses** were carried out to identify associations between individual competences and the overall domain ratings.

In line with the project's European policy focus, **only responses from European countries were included in the analysis**. The following 21 countries were represented in the final dataset:

Austria, Belgium, Bulgaria, Denmark, Estonia, France, Germany, Greece, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Switzerland, United Kingdom

Responses from **non-European countries and regions** – including **Kazakhstan, Kyrgyzstan, Uzbekistan**, and participants from the **African continent** – were excluded from analysis to ensure geographical consistency with the project's strategic scope.

All analyses were conducted using **SPSS** and aligned with the consolidated four-domain model as outlined in Section 2.1.2. The complete set of analytical outputs is documented in Chapter 4.2

3.3 Qualitative Design: Expert Interview Setup

To complement the desk research and quantitative survey, a qualitative study was conducted using **semi-structured expert interviews**. This third methodological pillar aimed to gain deeper, practice-oriented insights into emerging competence demands, validate the preliminary framework, and identify **nuanced skill gaps** specific to **mid-level technicians** in the context of **green and digital transformation**.

The qualitative approach was based on a uniform interview protocol and conducted in **March and April 2025** in five European countries. Experts were selected from **industry, applied research, and training institutions**, and were asked to reflect on the most critical future competences in their organizational context.

Note: The full interview guideline is documented in Annex 9.2.

The analysis of qualitative data focused on:

- Sector-specific future skill needs
- Gaps in technician profiles (EQF 5/6)
- Perceived barriers to competence development
- Requirements for hybrid profiles (interdisciplinary roles)

The insights gathered were used to:

- Validate and refine the competence descriptors developed in the desk research
- Contextualize the findings of the quantitative survey
- Support the creation of four technician **personas** (see Chapter 5.2)

Note: A detailed summary of the interview findings is presented in **Chapter 4.3**.

3.3.1 Methodological Approach

The qualitative approach followed a **scoping interview format**, combining **semi-structured guiding questions** with open-ended reflection prompts. The objective was to explore the most critical *technical and transversal competence needs* for mid-level technicians (EQF levels 5 and 6), especially in roles linked to applied research, innovation, and transformation tasks in advanced manufacturing settings.

The methodology was co-developed by WP leader **DHBW** and **CEA-PME**. While DHBW provided the conceptual framework and methodological tools, CEA-PME supported the design of the interview protocol and was responsible for conducting the interviews. Project partners (PPs) from five countries were asked to provide relevant industry contacts for interview recruitment.

3.3.2 Sample and Interview Process

- **Planned sample size**: 5–7 scoping interviews
- **Target group**: Company representatives, R&D managers, training coordinators, and domain experts from the partner countries
- **Recruitment**: Interviewees were nominated by project partners, primarily among stakeholders who had previously supported the quantitative survey
- **Interview mode**: Conducted via video conference or phone call in March 2025
- **Completion deadline**: All interviews were scheduled to be completed by **28 March 2025**

Each interview lasted between 30 and 60 minutes and followed a **uniform protocol**, including questions such as:

- “Which future-oriented competences will be most important for mid-level technicians in your organization?”
- “Which gaps do you observe in current technician profiles regarding research, innovation, or digital transformation?”
- “What sustainability-related skills are currently missing in your teams?”
- “What kinds of hybrid profiles or interdisciplinary capabilities do you consider strategically relevant?”

- “Could you describe a typical technician in your company who reflects these emerging demands?”

In addition to open questions on competence needs, selected interviews also included specific prompts to support the **development of four prototypical technician personas** (see Chapter 5.2).

Note: The complete interview guideline is provided in Annex 9.3.

3.3.3 Expected Output and Integration

The interviews were designed to produce two core outputs:

1. An **inventory of 20–30 key competence requirements** for future-oriented technical roles
2. The qualitative **basis for developing four persona profiles** that represent prototypical technician types across sectors and countries

The extracted competences were cross-validated against the results of the desk research and the quantitative survey and subsequently integrated into **Version 2 of the HUCO Future Skills Framework**. By capturing real-world transformation dynamics, the qualitative exploration added contextual depth to the competence model and ensured its practical relevance for European industrial innovation ecosystems.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

4 Research Results and Foundations for the TRIComp Framework

The following chapters (4.1 – 4.3) present the empirical implementation of the research designs outlined in Chapter 3.

4.1 Desk Research on Existing Competence Models and Preliminary Framework

To lay the foundation for the HUCO Labs Future Skill Framework, a comprehensive desk research phase was conducted. Using a structured Rapid Evidence Assessment (REA), the team systematically identified, analyzed, and consolidated competence constructs from leading European frameworks, including **DigComp**, **GreenComp**, **AIComp**, **EntreComp**, **NextSkills**, and **RECAPHE**.

The objective was to extract competence areas that are critical for mid-level technical professionals in the context of advanced manufacturing – particularly within the domains of research, innovation, digitalization, and green transformation. The extracted competences were compared across frameworks, grouped into meaningful categories, and evaluated for their relevance at EQF levels 5 and 6.

As an intermediate analytical step, the extracted competences were initially mapped to the conceptual triad of Research, Innovation, and Design, in alignment with the HUCO Labs project logic. While this mapping supported internal coherence during early synthesis, it was later replaced by the four-domain framework introduced in Section 2.1.1. This consolidated structure – comprising Innovation, Green Transformation, Digital, and Management – proved to be more aligned with both the empirical data and the functional realities of industrial R&D roles.

The following sections present the validated competence architecture resulting from this desk research. It serves as the analytical foundation for the subsequent empirical validation steps, described in Chapter

4.1.1 Consolidated Competence Domains Derived from Desk Research

The consolidated four-domain structure emerged from a functional synthesis of competence requirements across the reviewed frameworks. Rather than maintaining the five-domain model often found in individual sources (e.g., Research, Development, Innovation, Green, Digital), the HUCO Labs desk research revealed substantial thematic and operational overlaps – particularly between **Research & Innovation** and **Development & Management**.

The final framework comprises the following strategic competence domains:

- **Innovation Competences**
- **Management Competences**

- **Green Transformation Competences**
- **Digital Competences**

Each of these domains integrates competence elements from multiple frameworks and reflects a coherent, modular structure aligned with the objectives of the **European twin transition**. The consolidated domains also serve as the backbone for curriculum development, training program design, and competence-based assessment in vocational and higher education contexts.

This consolidated structure also serves as the foundation for the validated competence profiles presented in Section 4.1.2.

Analytical Mapping Phase – Intermediate Structuring Step

As part of the early synthesis phase, the extracted competences were provisionally mapped to the conceptual triad of **Research**, **Innovation**, and **Design**. This analytical step, based on the initial HUCO Labs project logic, aimed to ensure internal coherence and traceability.

Although later replaced by the four-domain model (Innovation, Green Transformation, Digital Transformation, Management; see Section 2.1.1), this preliminary mapping supported the alignment of theoretical foundations with operational competence profiles. Specifically:

- **Research Competences** covered systematic inquiry, evidence-based problem solving, and scientific communication (e.g. Design Research, Ethical Research, Interdisciplinary Collaboration, Communication).
- **Innovation Competences** reflected creative value generation and transformation leadership (e.g. Innovation Management, Problem-Solving, Entrepreneurship, Digital Simulation).
- **Design Competences** focused on technical implementation and iterative development (e.g. Development Skills, Project & Quality Management, Digital Solutions Design).

While no longer part of the final domain architecture, this conceptual mapping illustrates

4.1.2 Validated Competence Descriptions by Domain (Consolidated Structure)

The competence clusters identified through desk research were organized into four validated domains, each representing a strategic capability pillar for mid-level professionals in advanced manufacturing. The following section outlines these domains and details the individual competences embedded within them.

Innovation, Green Transformation, Digital Transformation, and Management.
Each competence integrates content from multiple European frameworks.

A - Innovation Competences

This domain integrates competencies related to the **application of research**, creative problem-solving, and interdisciplinary ideation processes. Frameworks such as **NextSkills**, **AIComp**, and **RECAPHE** emphasize the need for technicians to move beyond passive knowledge consumption and to actively shape innovative processes through design research, ethical reflection, and collaborative experimentation.

1. **Design Research Competence** – Competence in preparing, designing, and conducting research processes with a focus on innovation. This includes the ability to integrate subject-matter expertise, ethical considerations, and collaboration with stakeholders to ensure that research contributes to practical advancements and sustainable solutions (Rodrigues & Brunner, 2020).
2. **Ethical Research Competence** – Ability to apply research methods to practical, real-world problems and regional development, ensuring compliance with ethical, legal biases. This involves selecting appropriate methodologies, adapting them to industry and societal challenges, and ensuring that research findings effectively bridge the gap between theory and practice (Rodrigues & Brunner, 2020).
3. **Interdisciplinary Collaboration Competence** – Competence in integrating multiple disciplinary approaches to solve complex problems. This includes the ability to collaborate across fields, synthesize diverse perspectives, and apply appropriate methodologies to generate innovative, context-aware solutions that address real-world challenges (Rodrigues & Brunner, 2020).
4. **Communication Competence** – Ability to effectively communicate research findings to academic and industry stakeholders. This involves structuring complex information clearly, tailoring messages to different audiences, using appropriate language and media, and engaging in scholarly discussions to disseminate and defend research insights (Vurgun*, 2020).*
5. **Benchmark Orientation Competence** – Competence in integrating industry best practices and standards into research processes. This includes understanding regulatory frameworks, aligning research models with industrial benchmarks, and ensuring the applicability of findings in professional and industrial contexts (ITS Meccatronica Cuccovillo, 2023)
6. **Creativity & Problem-solving Competence** – Skill in applying creative methodologies to develop innovative solutions. It requires the ability to think flexibly, shift

perspectives, and integrate interdisciplinary insights to address challenges in novel and effective ways (Ehlers, 2020).

7. **Innovation Management Competence** – Competence in structuring and managing innovation processes. This entails facilitating collaboration, integrating feedback loops, and systematically advancing ideas from conception to implementation for maximum impact (Ehlers, 2020).
8. **Digital Simulation Competence** – Ability to apply digital modeling and simulation techniques to drive innovation. This includes using virtual environments to test, refine, and optimize new solutions in industrial and technological contexts. (ITS Meccatronica Cuccovillo, 2023).

B - Management Competences

This domain consolidates competencies originally attributed to "Development" and "Operational Coordination". It encompasses the transversal capabilities required to **initiate, plan, implement, and monitor** research and innovation activities in real-world settings. Strong emphasis is placed on quality assurance, entrepreneurial thinking, and applied project leadership.

1. **Project Management Competence** – Competence in planning and executing development projects in technical and industrial settings. Effective coordination of interdisciplinary teams, efficient resource management, and alignment with industry and regional needs are essential to ensure project sustainability and applicability (Rodrigues & Brunner, 2020).
2. **Research-Design-Competence** – Competence in organizing and managing a research process, from initiation to final publication. This entails strategic planning, resource allocation, risk management, and ensuring the quality, applicability, and sustainability of research outcomes in alignment with institutional and societal needs (Rodrigues & Brunner, 2020).
3. **Quality Management Competence** – Ensuring compliance with quality standards in development processes. This includes monitoring adherence to industry regulations, implementing continuous improvement strategies, and applying assessment frameworks to maintain high standards in product and process development (Rodrigues & Brunner, 2020).
4. **Entrepreneurial Competence** – Ability to identify market opportunities and develop innovative solutions. Ability to identify market opportunities and develop innovative solutions. This involves recognizing emerging trends, evaluating risks, and leveraging creativity and strategic decision-making to drive value creation in dynamic and complex environments (Ehlers, 2020).

C – Green Transformation Competences

This domain emerged from a synthesis of **GreenComp**, **RECAPHE**, and sustainability-centered engineering models. It reflects the imperative to embed **life-cycle thinking**, ecological literacy, and systems-based sustainability into technical roles. Competences in this domain enable mid-level professionals to actively contribute to the **twin transition** through systemic and circular design strategies.

1. **Systems Thinking Competence** – Ability to evaluate the environmental impact of products and processes. This involves applying systems thinking to assess life cycle impacts, identifying sustainability trade-offs, and integrating ecological, social, and economic factors into decision-making for responsible resource management (Bianchi et al., 2022).
2. **Sustainability Competence** – Knowledge, Skills, Attitudes to implement sustainable production and waste management models. Effective application requires fostering systemic change, designing resource-efficient processes, and promoting reuse, repair, and recycling practices to minimize environmental impact (Bianchi et al., 2022)
3. **Systems Design Competence** – Knowledge, Skills, Attitudes to deal with renewable energy systems and their application. This includes evaluating energy sources for sustainability, optimizing their use in various contexts, and aligning technical solutions with ecological and policy frameworks for a just energy transition (Bianchi et al., 2022)

D - Digital Competences

Digital capabilities are considered transversal, yet a distinct domain was established to reflect the advanced role of **data literacy**, **cybersecurity**, **AI integration**, and **cloud-based systems** in modern industrial settings. Drawing primarily from **DigComp**, **AIComp**, and **Cuccovillo Foundation Curriculum**, this domain outlines the digital foundation for resilient, future-proof technical operations.

1. **Digital Literacy** – Competence in effectively using digital tools and platforms. This includes the ability to critically assess digital content, manage digital identities, and adapt to evolving technologies while ensuring accessibility and ethical considerations in digital environments. Additionally, it involves the application of agile working methods in digital transformation processes, enabling iterative development, adaptive problem-solving, and cross-functional collaboration in industrial automation and technological innovation (Vuorikari et al., 2022; ITS Meccatronica Cuccovillo, 2023).

2. **Cybersecurity Competence** – Knowledge of cybersecurity principles and risk mitigation strategies. It involves recognizing digital threats, implementing protective measures such as strong authentication and encryption, and fostering a security-conscious mindset to safeguard data and privacy (Bianchi et al., 2022)
3. **Data Competence** – Ability to analyze and interpret large datasets for decision-making. This includes selecting appropriate data sources, applying analytical techniques to identify patterns and trends, and using visualization tools to communicate insights effectively while ensuring data privacy and ethical use (Bianchi et al., 2022)
4. **AI Competences** – Understanding of artificial intelligence applications and ethical implications. This includes the ability to critically evaluate AI systems, recognize their societal and organizational impact, and apply AI responsibly while ensuring transparency, fairness, and accountability in decision-making processes (Ehlers et al., 2023).
5. **Cloud Manufacturing Competence** – Competence in utilizing cloud computing and digital platforms for manufacturing and automation. This includes optimizing workflows, enabling remote monitoring and control, and integrating cloud-based AI analytics for predictive maintenance and decision-making (ITS Meccatronica Cuccovillo, 2023).
6. **Digital Solutions Design Competence** – Skill in developing and optimizing software solutions for automation and digital process control. This includes applying coding knowledge to industrial and technological applications, ensuring system reliability, and integrating emerging digital tools (ITS Meccatronica Cuccovillo, 2023).

4.2 Survey-Based Analysis of Future Skill Priorities in Europe

Starting from Section 4.2, the Research Results are presented using the updated competence names. This approach ensures logical traceability, as otherwise the figures and tables would not align with the subsequent terminology. The renaming is based on the results gathered from both the qualitative and quantitative data. For transparency, Appendix 9.9 provides a 1:1 mapping table of all changes, while the original questionnaire with the former labels is included in Section 9.3.

To build on the findings of the desk research and validate the relevance of identified competences, a quantitative survey was conducted among stakeholders, including representatives from higher vocational education and training (HVET), industry, and applied research institutions. The aim was to assess the perceived importance and strategic impact of Future Skills across four key domains:

- Innovation Competence (Part A)
- Management Competence (Part B)
- Green Transformation Competence (Part C)
- Digital Competence (Part D)

The survey included both overall importance ratings for each domain and detailed assessments of individual sub-competences. Respondents rated items on a 5-point Likert scale (1 = not important, 5 = very important). Standard deviations were calculated to assess variance in responses.

A total of **169 fully completed questionnaires** were collected in the survey. For the main statistical analyses presented in sections **4.2.1 to 4.2.4**, a focused subset of **150 participants from European countries** was used. This European sample includes responses from the following countries: **Austria, Belgium, Bulgaria, Denmark, Estonia, France, Germany, Greece, Ireland, Italy, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Switzerland, and the UK.**

The remaining respondents in the full sample (n = 169) came from outside Europe, including several **African** countries as well as **Uzbekistan, Kazakhstan, and Kyrgyzstan**. While these additional cases were **not included in the statistical analyses** of competence ratings (sections 4.1.1–4.1.5), they were **considered for descriptive visualizations**, such as the **educational attainment** and **technical field of work** of typical technicians. These contextual charts (see Section 3) provide a broader perspective on technician profiles, but are not directly comparable to the EU-focused analytical results.

The following charts (Figures 4 and 5) provide contextual background information on the technician workforce represented in the survey (n = 169, full sample including non-EU countries).

Figure 4 illustrates the **primary occupational fields** of technicians, with *Mechanical & Electrical Engineering*, *Computer Science / IT*, and *Technical Engineering* emerging as the most common domains (over 50% each). This reflects the technological concentration and applied nature of the sample.

Note: These distributions serve as descriptive reference points only. They are *not aligned* with the seven sector categories used in the comparative variance analysis (Section 4.2.3) and were not used for segmentation in the modelling

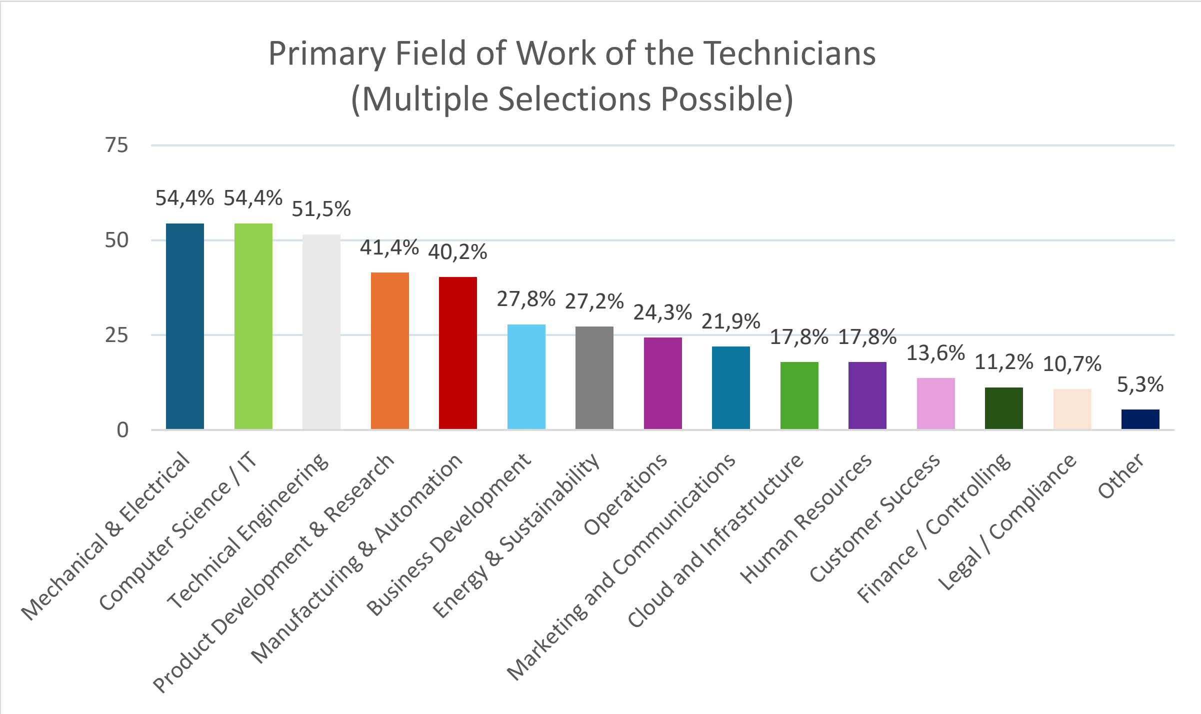

Figure 4: Primary Work Fields of Technicians ((Multiple Answers Possible; n = 169, full sample incl. non-EU countries)

Figure 5 displays the **highest level of educational attainment** typically reported for technicians in each organization. The majority of respondents indicated **Bachelor's (EQF 6)** or **Master's degrees (EQF 7)** as the predominant qualification levels, highlighting the advanced educational profile of mid-level professionals.

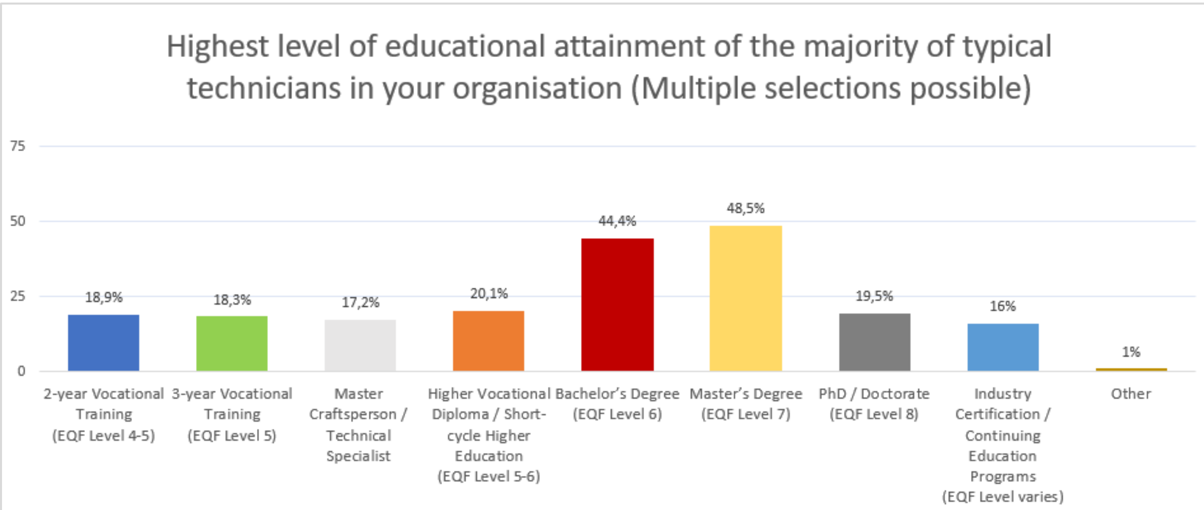

Figure 5: Highest Level of Educational Attainment of the Majority of Typical Technicians (Multiple Answers Possible, n = 169, full sample incl. non-EU countries)

4.2.1 Key Trends and Priorities (EU)

To identify broad competence priorities across the four domains, mean importance values and standard deviations were analyzed. The following horizontal bar charts provide a comparative overview. Figure 6 provides a visual overview of the perceived relevance of innovation competences for mid-level technicians.

Part A: Innovation Competences

Figure 6 shows the mean importance ratings and standard deviations for innovation-related Future Skills (Part A), based on the responses of 150 stakeholders.

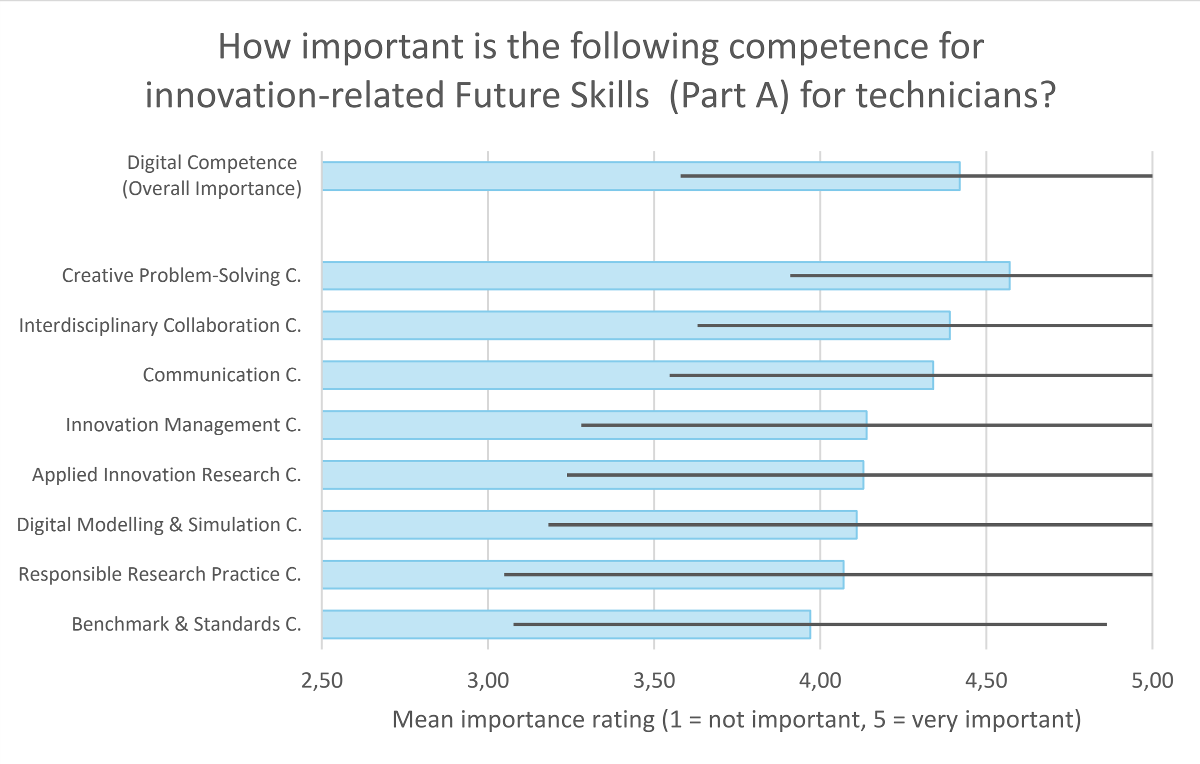

Figure 6: Mean importance ratings and SD for Part A - Innovation Competences (n = 150; Bars show mean values; error bars show ±1 standard deviation)

The domain of Innovation Competences displays consistently high importance ratings across all sub-competences, indicating strong agreement on their strategic relevance for technician roles at EQF Level 5–6. However, the variance in standard deviations points to underlying differences in interpretation and priority-setting among stakeholders:

- **Creativity-Problem-Solving Competence** received the highest rating (**M = 4.57, SD = 0.66**), suggesting universal recognition of its core role in innovation-oriented work environments.
- **Interdisciplinary Collaboration Competence** (**M = 4.39, SD = 0.76**) and **Communication Competence** (**M = 4.34, SD = 0.79**) also ranked highly, but their

higher standard deviations suggest differences in institutional emphasis or contextual application.

- **Innovation Management Competence** (**M = 4.14, SD = 0.86**) and **Applied Innovation Research Competence** (**M = 4.13, SD = 0.83**) are rated as moderately important but may be undervalued relative to their potential impact in enabling structured innovation processes.
- **Digital Modelling & Simulation Competence**, **Benchmark & Standards Competence**, and **Responsible Research Practice Competence** form the lower tier (**M = 4.11–3.97, SD = 0.93–1.22**), revealing greater ambivalence – potentially due to role-specific exposure or ambiguity in operational expectations.

In sum, Creativity-Problem-Solving is clearly seen as the foundation of innovation competence, but the wider variance in supporting sub-domains calls for clearer role definitions and differentiated curricular strategies to better equip technicians at mid-level qualification stages.

Part B: Management Competences

Figure 7 presents the mean importance ratings and standard deviations for the four management-related Future Skills (Part B), based on stakeholder responses (n = 150).

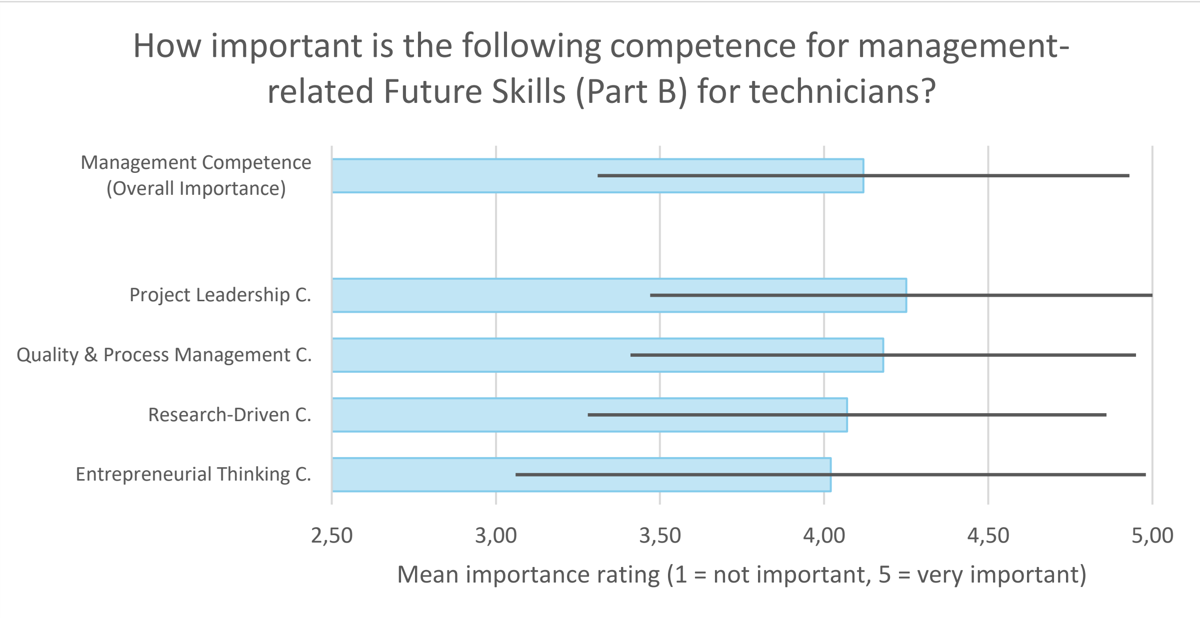

Figure 7: Mean importance ratings and SD for Part B - Management Competences (n = 150; Bars show mean values; error bars show ±1 standard deviation)

All four management competences received high relevance ratings, but diverging standard deviations reveal strategic tensions:

- **Project Leadership Competence** (**M = 4.25, SD = 0.78**) and **Quality & Process Management Competence** (**M = 4.18, SD = 0.77**) dominate the profile, indicating their essential role in structuring technician-led R&D.

- **Research-Driven Competence** (**M = 4.07, SD = 0.79**) demonstrates significant but perhaps underestimated value – especially for technician roles increasingly involved in evidence-based innovation.
- **Entrepreneurial Thinking Competence** (**M = 4.02, SD = 0.96**) shows the widest range of opinions, reflecting differing expectations about the proactive role of EQF 5 – 6 profiles in opportunity recognition and value creation.

Overall, the data highlight a firm grounding in execution-oriented skills, while signaling a missed opportunity to integrate higher-order capabilities. Curricula should seek to elevate underrepresented competences to enhance strategic readiness.

Part C: Green Transformation Competences

Figure 8 displays the mean importance ratings and standard deviations for green transformation-related Future Skills (Part C), based on stakeholder responses (n = 150).

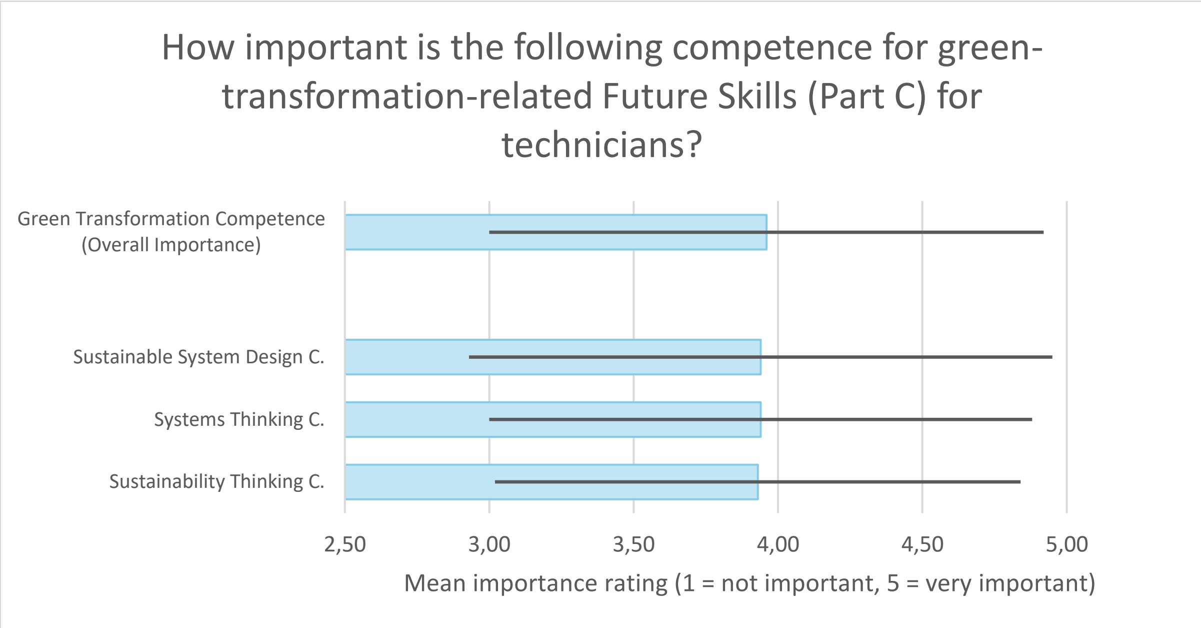

Figure 8: Mean importance ratings and SD for Part C – Green Transformation Competences (n = 150; Bars show mean values; error bars show ±1 standard deviation)

Compared to other domains, green competences scored lower in perceived importance and showed more variability:

- **Systems Thinking Competence** (**M = 3.94, SD = 0.94**), **Sustainability Thinking Competence** (**M = 3.93, SD = 0.91**), and **Sustainable Systems Design Competence** (**M = 3.94, SD = 1.01**) were evaluated similarly, though the higher deviations – particularly for Systems Design – suggest divergent views on applicability and operationalization.

This implies that despite policy-driven imperatives, many technician profiles at EQF 5 – 6 may not yet be systematically integrating sustainability principles. Differences in sectoral maturity and unclear role expectations likely contribute to these ambiguities.

In sum, this domain reveals a notable implementation gap: while policy ambitions are high, the systematic integration into technician profiles remains limited.

Part D: Digital Competences

Figure 9 presents the mean importance ratings and standard deviations for digital competence-related Future Skills (Part D), based on stakeholder responses (n = 150).

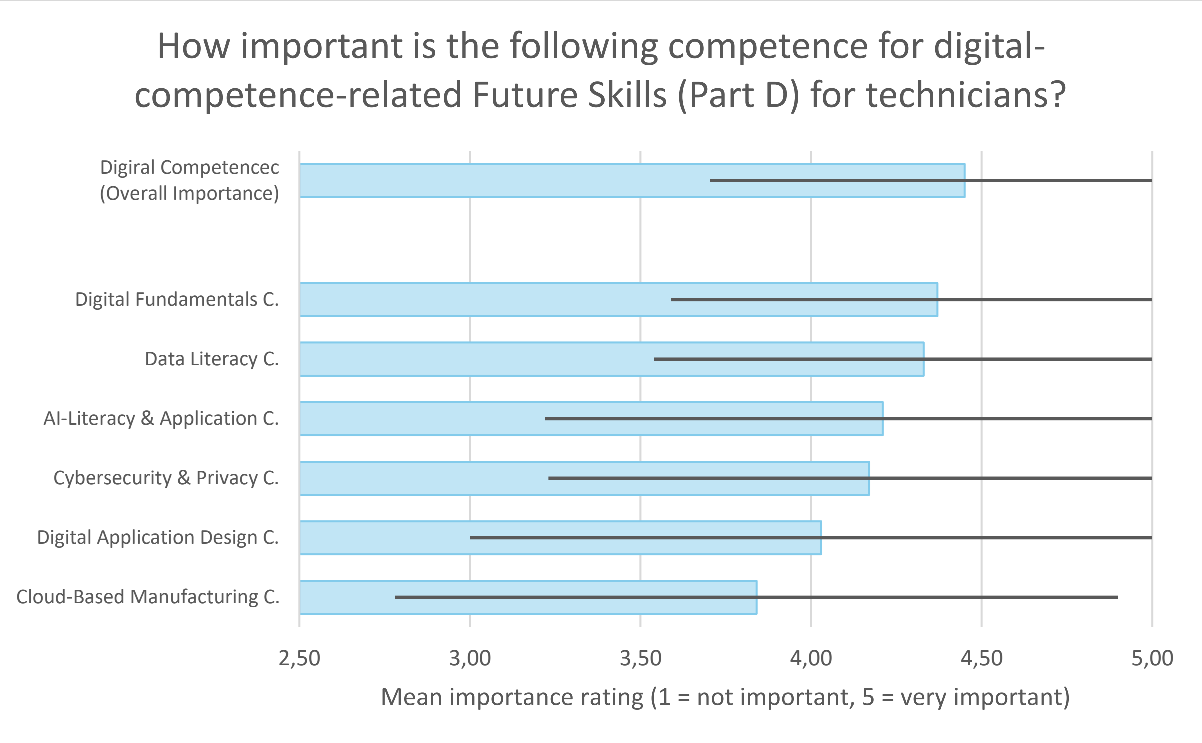

Figure 9: Mean importance ratings and SD for Part D – Digital Competences (n = 150; Bars show mean values; error bars show ±1 standard deviation)

Digital competences remain central to technician preparedness, but differences in familiarity and technical readiness result in a layered profile:

- **Digital Fundamentals Competence** leads with the highest score (**M = 4.37, SD = 0.75**), confirming its foundational role.
- **Data Literacy Competence** (**M = 4.33, SD = 0.79**) and **AI Competence** (**M = 4.21, SD = 0.90**) also score highly but reflect slightly more divergence in perceived importance.
- **Cybersecurity & Privacy Competence** (**M = 4.17, SD = 0.95**) ranks lower, potentially due to its domain-specific integration rather than general applicability.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

- **Digital Application Design Competence** (**M = 4.03, SD = 0.91**) and **Cloud-Based Manufacturing Competence** (**M = 3.84, SD = 1.06**) are the least prioritized – both in terms of familiarity and perceived urgency.

Overall, these findings underscore a stratified digital readiness. While core skills are widely acknowledged, advanced digital infrastructure topics are not yet mainstreamed into EQF 5 – 6 profiles – despite their growing strategic relevance.

Summary of Key Findings and Strategic Outlook

The descriptive analysis reveals both shared priorities and strategic uncertainties in European technician training. While core transversal competences such as Creative-Problem-Solving Competence (M = 4.57), Digital Fundamentals Competence (M = 4.37), and Project Leadership Competence (M = 4.25) are widely accepted, other competences such as Cloud-Based Manufacturing Competence (M = 3.84), Sustainable System Design Competence (M = 3.94), and Entrepreneurial Thinking Competence (M = 4.02) show higher standard deviations and lower means – suggesting heterogeneity in expectations and varying curricular integration.
These trends are explored in more depth through correlational analysis in the following section, which helps distinguish core priorities from blind spots.

4.2.2 Relevance Matrix (EU)

In addition to descriptive analysis, a relevance matrix was constructed for each domain. This two-dimensional mapping visualizes the relationship between (1**) mean importance ratings and** (2**) correlation of each sub-competence with the overall domain rating**. This Reflects the item's correlation to the explained variance of the primary variable. Four quadrants have been constructed:

- Core Competences: above average relevance, above average correlation
- Hidden Potentials: below average relevance, above average correlation
- Perceived Priorities Competences: above average relevance, below average correlation
- Background Competences: below average relevance, below average correlation

Core competences

Competences that are perceived as highly relevant and show a strong statistical correlation to the domain construct. They represent the essential pillars of the domain and should be prioritized in development and implementation.

Hidden potentials

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Competences with below-average perceived relevance but above-average statistical correlation. Although underrecognized, they play a significant role and may hold untapped strategic value.

Perceived priorities

Competences that are rated as highly important by stakeholders but show only weak correlation with the overall competence construct. Their high subjective relevance contrasts with their limited empirical impact, indicating the need for critical reassessment.

Background competences

Competences with low perceived importance and low statistical correlation. They are marginal to the domain's identity and may be considered lower priority in strategy or curriculum design.

Figure 10 provides a visual explanation of how the relevance matrices are interpreted. Each sub-competence is positioned along two axes: its **average perceived importance** (Y-axis) and its **statistical correlation with the overall domain construct** (X-axis). All correlations are significant at the 0.01 level (2-tailed).

This matrix serves as a data-driven tool to identify and prioritize competencies within each domain. The four quadrants indicate different strategic roles, from core competences to hidden potentials.

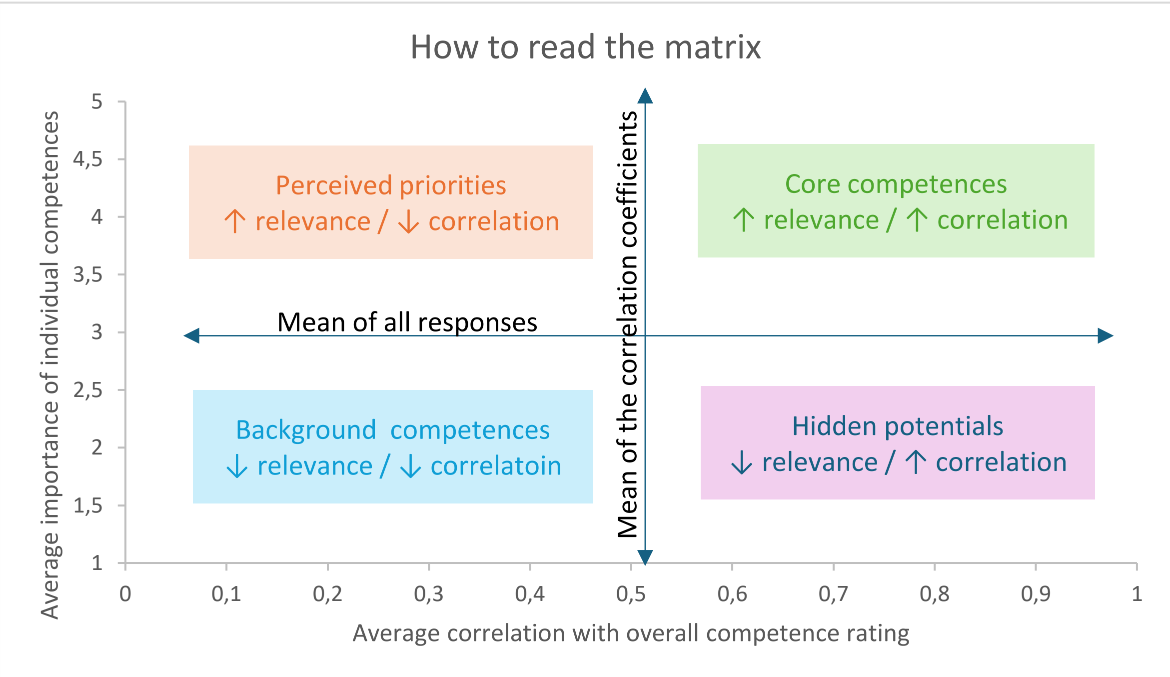

Figure 10: Interpretation guide for relevance matrices

Based on this conceptual model, the following sections present the results per domain.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Relevance matrix part A: Innovation competence

The following matrix (Figure 11) shows the position of each sub-competence for Innovation Competence along two axes: average importance (Y-axis) and its correlation with the aggregated subscale score of the domain (X-axis). All correlations are significant at the 0.01 level (2-tailed).

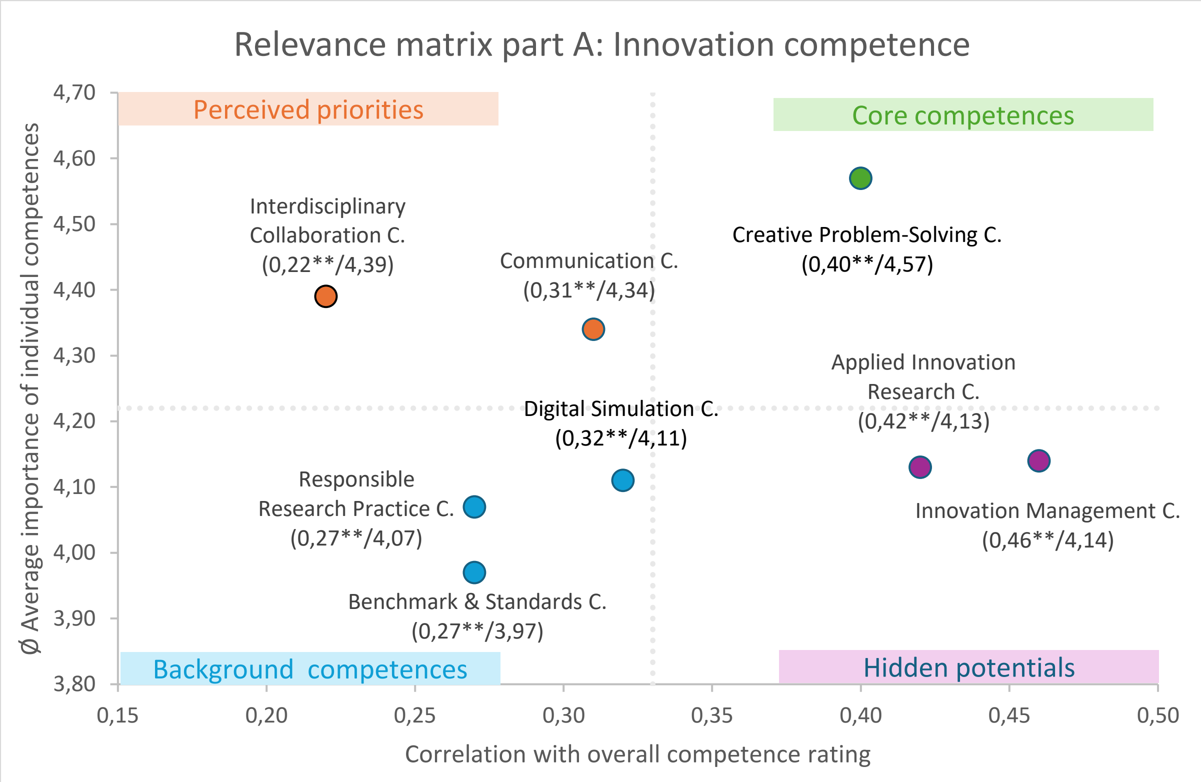

Figure 11: Relevance matrix Innovation competence (Part A ; n=150)

The relevance matrix visualizes the relationship between the perceived importance and the statistical relevance of eight innovation-related sub-competences. This visualization enables a precise identification of which competences are both subjectively valued and objectively central to the broader innovation competence domain.

Core competence:

Creative Problem-Solving Competence (r = .40**, M = 4.57.) This is the only competence clearly located in the top-right quadrant, signifying both high perceived importance and strong statistical relevance. It stands out as the foundational driver of innovation activities and should be at the core of any innovation-related training and upskilling efforts.

Perceived priorities competence:

Communication Competence (r = .31**, M = 4.34) and *Interdisciplinary Collaboration Competence* (r = .22**, M = 4.39). Both competences are highly rated in terms of perceived relevance, but show weaker correlations with the overall construct. Their position suggests they may be valued more for their general professional appeal than for their specific contribution to innovation competence.

Hidden potentials:

Applied Innovation Research Competence (r = .42**, M = 4.13) and *Innovation Management Competence* (r = .46**, M = 4.14). These competences are located in the lower-right quadrant, indicating a strong correlation with overall innovation competence but only moderate perceived importance. This suggests they are underutilized or undervalued in current training programs, despite their strategic potential.

Background competences:

Digital Modelling & Simulation Competence (r = .32**, M = 4.11), *Benchmark & Standards Competence* (r = .27**, M = 3.97), and *Responsible Research Practice Competence* (r = 0.27**, M = 4.07). These competences occupy the lower-left quadrant, reflecting both limited perceived relevance and weaker predictive correlation. While they may play a supportive role in specific contexts, they currently hold less strategic weight in the broader innovation profile.

Summary:

The revised matrix confirms **Creative Problem-Solving** as the undisputed core competence for fostering innovation among EQF Level 5-6 professionals. At the same time, competences such as **Applied Innovation Research** and **Innovation Management** demonstrate high strategic value but remain underprioritized. Conversely, competences like **Interdisciplinary Collaboration** and **Communication**, while popular, contribute less directly to innovation-specific skill development. These insights emphasize the importance of evidence-based curriculum design that balances perception with measurable impact.

Relevance matrix part B: Management competence

The following matrix (Figure 12) shows the position of each sub-competence for Management Competence along two axes: average importance (Y-axis) and its correlation with the aggregated subscale score of the domain (X-axis). All correlations are significant at the 0.01 level (2-tailed).

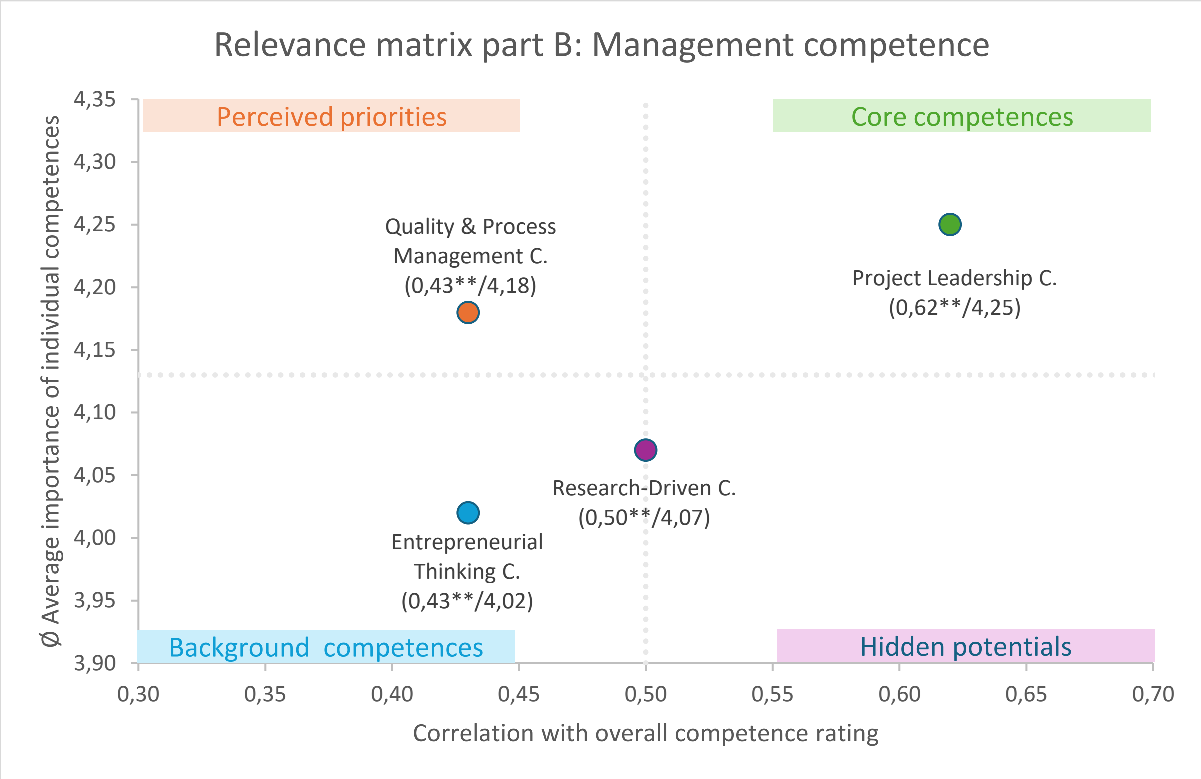

Figure 12: Relevance matrix management competence (Part B ; n=150)

The matrix plots four individual management-related competences along two dimensions: their average perceived importance (Y-axis) and their correlation with the overall domain rating (X-axis). The resulting quadrant structure highlights strategic leverage points for competence development.

- **Core competence**:

  Project Leadership Competence (r = .62**, M = 4.25). This competence is clearly located in the upper-right quadrant, combining the highest correlation with strong perceived relevance. It stands out as the central pillar of management competence for mid-level professionals and should be firmly anchored in any R&D- and innovation-related training program.

- **Perceived priorities competence**:

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Quality & Process Management Competence (r = .43**, M = 4.18). Despite being perceived as highly important, this competence shows a noticeably lower correlation with the overall management domain. This discrepancy suggests that while quality assurance is considered essential, it may represent more of a standard baseline than a true strategic driver of management innovation.

🟦 **Hidden potential**:

Research-Driven Competence (r = .50**, M = 4.07). Positioned just below the core quadrant, this competence demonstrates high statistical relevance but is rated only moderately important. This gap suggests unrecognized strategic value, particularly in evidence-based innovation and structured development processes.

🟪 **Background competences**:

Entrepreneurial Thinking Competence (r = .43**, M = 4.02). With lower values on both axes, this competence currently appears to play a more peripheral role in the management profiles of EQF Level 5 professionals. However, its relevance may grow in the context of decentralized innovation and opportunity creation, especially if role expectations are clarified and supported by tailored training formats.

Summary:

While **Project Leadership Management** is clearly confirmed as the core management competence, the matrix points to a strategic blind spot: **Research-Driven Competence** is undervalued despite its measurable correlation. Meanwhile, **Quality & Process Management** and **Entrepreneurial Thinking Competence**, though appreciated, appear less predictive of innovation-oriented management.

These findings highlight the need for differentiated curricular design – moving beyond tradition-based prioritization toward evidence-driven development of management capacities that align with future skills demands.

Relevance Matrix Part C: Green transformation competence

The following matrix (Figure 13) shows the position of each sub-competence for Green Transformation Competence along two axes: average importance (Y-axis) and its correlation with the aggregated subscale score of the domain (X-axis). All correlations are significant at the 0.01 level (2-tailed).

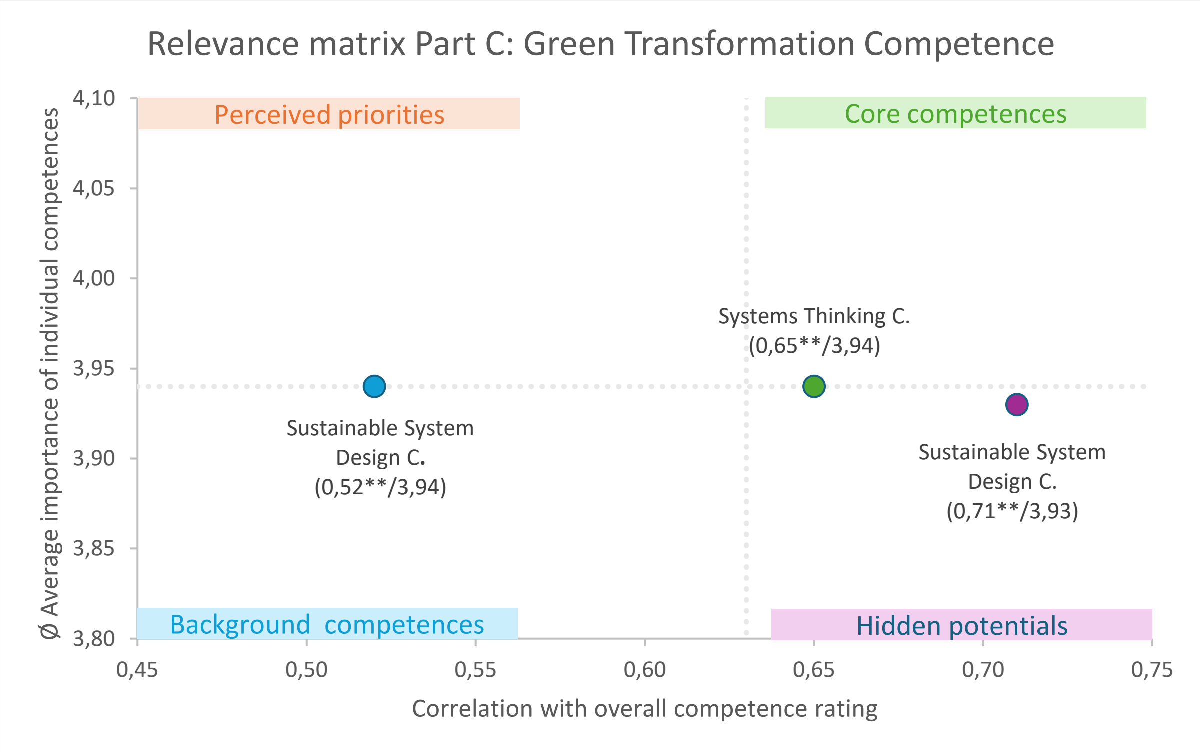

Figure 13: Relevance matrix : green transformation competence (Part C; n=150)

This matrix visualizes the alignment between perceived relevance and statistical centrality for three sub-competences in the green transformation domain. Although mean importance ratings are slightly lower compared to other domains, the correlation strength demonstrates a high level of strategic relevance for several competences.

This matrix illustrates how individual green transformation competences are positioned in relation to their perceived importance (Y-axis) and their statistical correlation with the overall domain rating (X-axis). Three competences were analyzed, resulting in a nuanced picture of strategic alignment and perception gaps:

- **Core competence**:

  System Thinking Competence (r = .65**, M = 3.94). Positioned in the upper-right quadrant, Systems Thinking emerges as a statistically robust and well-perceived core competence. It reflects the growing recognition that holistic thinking and

Co-funded by
the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

interconnectivity are essential for addressing complex ecological, technological, and organizational transformation processes.

🟦 **Hidden potential**:

Sustainability *Thinking* Competence (r = .71**, M = 3.93). Despite being equally valued as Systems Thinking, this competence shows an even stronger correlation with the overall green transformation profile – indicating a potential undervaluation in perception. Its strategic relevance is undeniable, and it should be treated as a foundational component in curricula focused on ecological literacy and long-term resilience.

🟥 **Perceived priorities competence**:

Sustainable Systems Design Competence (r = .52**, M = 3.94). This competence shares the same importance rating as the other two, but its comparatively lower correlation suggests it may be overestimated in its strategic impact. The result points to a potential misalignment between technical design capabilities and the broader goals of green innovation. Clarification of its role is needed, particularly in relation to system implementation versus transformation leadership.

Conclusion:
The relevance matrix highlights a pressing need to recalibrate the pedagogical approach to green transformation skills. While **Systems Thinking Competence** and **Sustainability Thinking Competence** demonstrate strong and measurable relevance, **Sustainable Systems Design** appears overemphasized relative to its strategic correlation.

This calls for an integrated competence development model in which **systems-based reflection** and **sustainability-oriented action** are advanced jointly. Only then can future professionals effectively contribute to and lead ecological and systemic transformation in industry and society.

Relevance Matrix Part D: Digital Competence

The following matrix (Figure 14) shows the position of each sub-competence for Digital Competence along two axes: average importance (Y-axis) and its correlation with the aggregated subscale score of the domain (X-axis). All correlations are significant at the 0.01 level (2-tailed).

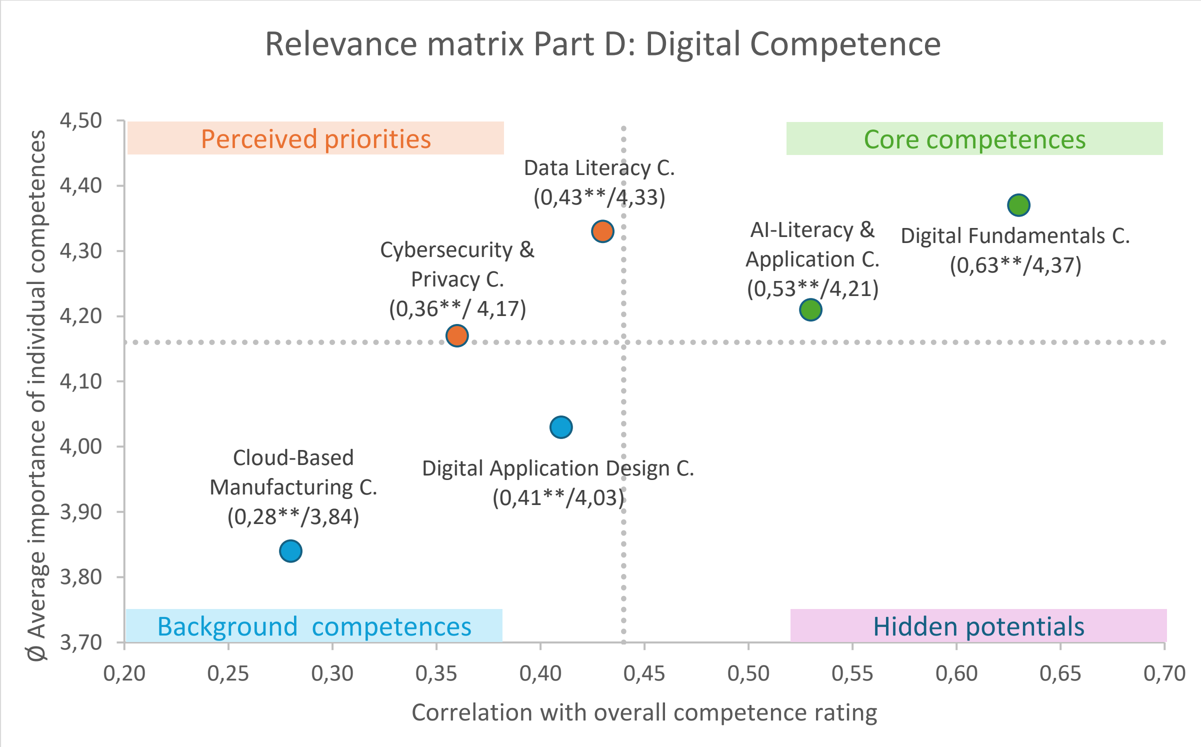

Figure 14: Relevance matrix Digital Competence (Part D ; n=150)

This matrix visualizes six digital-related sub-competences by plotting their perceived importance and statistical correlation. The quadrant structure allows for a clear distinction between strategic core competences, overvalued priorities, and currently marginal skill areas.

- **Core competences:**

Digital Fundamentals Competence (r = .63**, M = 4.37), *AI-Literacy & Application Competence* (r = .53**, M = 4.21). Both competences are situated in the upper-right quadrant, confirming their status as essential components of the digital competence profile. Their prominence reflects the increasing demand for digitally literate and AI-informed professionals across all technical sectors.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

🟥 **Perceived priorities competence**:

Data Literacy Competence (r = .43**, M = 4.33), *Cybersecurity & Privacy Competence* (r = .36**, M = 4.17). Despite their high perceived importance, these competences show relatively low correlations with the overall domain score. This discrepancy points to a potential overestimation of their strategic value at EQF Level 5-6 – or an ongoing gap between expectation and implementation in practice.

🟪 **Background competence**:

Cloud-Based Manufacturing Competence (r = .28**, M = 3.84), Digital Application Design Competence (r = .41**, M = 4.03). These competences are placed in the lower-left quadrant of the matrix, suggesting a more peripheral role in the current digital landscape. While both areas may gain relevance in the future, they currently appear to be either underdeveloped or applied only in specific niche contexts.

Conclusion:
The updated relevance matrix highlights **Digital Fundamentals Competence** and **AI-Literacy & Application Competence** as the undisputed digital core skills for mid-level professionals. Meanwhile, **Data Literacy Competence** and **Cybersecurity & Privacy Competence** appear as **perceived priorities** – rated highly, but less aligned with strategic digital performance.

Cloud-Based Manufacturing and **Digital Application Design** are currently classified as **background competences**, with limited reach in technician-level profiles. These findings call for focused investment in **foundational digital skills**, while background competences may require **targeted development** in specialized fields or in preparation for future shifts in industrial digitalization.

Synthesis Report: Strategic Priorities and Blind Spots Across Four Future Skill Domains (A–D)

The four relevance matrices developed in HUCO Labs (Innovation, Management, Green Transformation, Digital) provide a data-driven synthesis of stakeholder perceptions regarding the importance and strategic weight of specific Future Skills for mid-level technicians. By plotting the average importance of each sub-competence against its statistical correlation with the overall domain construct, the matrices enable a structured differentiation between core competences, undervalued levers, and overestimated elements.

Part A: Innovation Competence

- 🟧 **Core competence:**
  Creative Problem-Solving (M = 4.57; r = .40**) emerges as the clear strategic anchor – combining high perceived relevance with robust predictive strength.
- 🟦 **Hidden potentials:**
  Applied Innovation Research (M = 4.13; r = .42**) and *Innovation Management* (M = 4.14; r = .46**) demonstrate significant strategic relevance but are comparatively undervalued.
- 🟥 **Perceived priorities competences:**
  Communication (M = 4.34; r = .31**) and *Interdisciplinary Collaboration* (M = 4.39; r = .22**) receive high importance ratings but contribute less clearly to the domain construct.
- 🟪 **Background competences:**
  Responsible Research Practice, *Benchmark & Standards Orientation*, and *Digital Modelling & Simulation* show weaker scores on both axes.

Insight:
Innovation is predominantly framed as a creative process, while research-based and management-related enablers are systematically undervalued. Popular competences such as communication may reflect general professionalism but lack strategic weight in this specific context.

Part B: Management Competence

- 🟧 **Core competence:**
  Project Leadership (M = 4.25; r = .62**) stands out with the strongest correlation across all domains, highlighting its structural centrality.
- 🟦 **Hidden potential:**
  Research-Driven Competence (M = 4.07; r = .50**) is highly relevant yet not prioritized accordingly.
- 🟥 **Perceived priorities competence:**
  Quality & Process Management (M = 4.18; r = .43**) is consistently valued but less predictive of the management domain.
- 🟪 **Background competence:**
  Entrepreneurial Thinking Competence (M = 4.02; r = .43**) plays a peripheral role, possibly due to unclear expectations regarding technician-led innovation.

Insight:

Management competence in technician profiles revolves around coordination and operational structure. However, the undervaluation of research- and innovation-enabling capabilities points to a strategic development gap in curricula and training programs.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

Part C: Green Transformation Competence

- 🟧 **Core competence:**
  Systems Thinking (M = 3.94; r = .65**) combines moderate perceived relevance with high strategic correlation.
- 🟦 **Hidden potential:**
  Sustainability Thinking Competence (M = 3.93; r = .71**) shows the strongest correlation in the domain but lacks visibility.
- 🟥 **Perceived priorities competence:**
  Sustainable Systems Design (M = 3.94; r = .52**) is valued similarly but less central in predictive terms.

Insight:

While sustainability is accepted as a guiding value, the ability to think systemically and implement green strategies remains underdeveloped. Sustainable System Design skills appear overestimated, reflecting a potential misalignment between technical implementation and systemic transformation capacity.

Part D: Digital Competence

- 🟧 **Core competences:**
  Digital Fundamentals (M = 4.37; r = .63**) and *AI-Literacy & Application Competence* (M ≈ 4.21; r ≈ .53**) are both highly relevant and statistically central.
- 🟥 **Perceived priorities competences:**
  Data Literacy Competence (M = 4.33; r = .43**) and *Cybersecurity & Privacy* (M = 4.17; r = .36**) are valued but less predictive of the digital competence construct.
- 🟪 **Background competences:**
  Digital Application Design (M = 4.03; r = .41**) and *Cloud Manufacturing* (M = 3.84; r = .28**) are positioned as peripheral skills.

Insight:

Foundational digital skills such as literacy and AI & Application integration are well embedded. However, data and security competences – despite their popularity – are less strategically integrated, while specialized areas like cloud and systems design remain marginal. This indicates a fragmentation of digital capacity-building and calls for clearer role orientation.

Contextual Note:

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

While the relevance matrices offer clear strategic distinctions between core, hidden, perceived priorities, and background competences, it must be emphasized that *all* sub-competences are relevant and necessary for holistic professional capacity.

Their position in the matrix reflects stakeholder perceptions within this study and may vary across countries, sectors, and educational settings. National innovation strategies, organizational cultures, or institutional missions (e.g., applied vs. research-oriented) can all shape the weighting of competences. The relevance matrix should therefore be read as a strategic guidance tool – not a rigid evaluation framework.

Cross-Domain Synthesis: Patterns and Strategic Leverage Points

Table 6 synthesizes cross-domain insights from the relevance matrix analysis, summarizing key strategic patterns across the four competence areas. It highlights three dimensions for each domain:

(1) the core strategic theme,
(2) undervalued leverage points, and
(3) observed tensions in stakeholder perceptions.

This synthesis supports a deeper understanding of transformation-relevant skill dynamics and serves as a basis for policy and curriculum design.

Table 6: Strategic Categorization of Competences by Domain and Functional Role

Domain	Core Strategic Theme	Undervalued Lever	Observed Tension
Innovation	Creativity as the driving force	Research & Innovation Management	Communication valued, but weak predictor
Management	Project-led coordination	Research-Design structuring	Entrepreneurship remains peripheral
Green Transformation	Systems thinking as integration logic	Sustainability & Systems reflection	Systems Design perceived as technical, not systemic
Digital	Digital literacy as infrastructure & AI Competence	AI readiness vs. data/security misalignment	Coding & cloud viewed as peripheral or undefined

Strategic Implications for Policy and Curriculum Design

1. **Anchor integrated competence clusters** rather than isolated skills – e.g., combining AI + Responsible Research + Project Management to reflect the complexity of applied transformation work.

2. **Elevate undervalued high-correlation competences** (e.g., Systems Thinking, Research-Driven, Responsible Innovation) to secure long-term capacity and adaptability.
3. **Clarify technician roles in innovation ecosystems**: From passive executors to active shapers, technicians need training that supports their strategic function in transformation, sustainability, and digitalization processes.

4.2.3 Sectoral Differences in the Perceived Importance of Future Skill Domains (Based on Overall Ratings) (EU)

To explore potential sector-specific priorities, participating organizations were grouped into the following seven industry categories:

1. Manufacturing & Industry
2. ICT & Digitalization
3. Construction & Engineering
4. Education, Research & Health
5. Agriculture & Environment
6. Services & Consulting
7. Other sectors

For this analysis, the **overall domain ratings** were used as dependent variables (e.g., "How do you rate the overall importance of Innovation Competences...?"), rather than individual sub-competences. This approach enables a focused comparison of sectoral perceptions regarding the **general strategic relevance** of each Future Skills domain (Innovation, Management, Green Transformation, Digital).

A) Innovation Competences

A univariate ANOVA revealed **marginally significant sectoral differences** in the perceived importance of innovation competences ($F(6,143) = 2.16$, $p = .051$, ηp^2 [15] $= .083$, ω^2 [16]$=.044$). The highest mean ratings were observed in **Construction & Engineering (M = 4.52)** and **Education, Research & Health (M = 4.52)**, while the lowest came from **Services & Consulting (M = 4.00)** and **Agriculture & Environment (M = 4.00)**. While overall importance ratings remained high across all sectors, the marginally significant differences suggest that

[15] ηp^2 values represent effect sizes from the ANOVA. According to Cohen (1988), ηp^2 values of 0.01 = small effect, 0.06 = medium effect, 0.14 = large effect.
[16] For ω^2, values represent effect sizes from ANOVA. ω^2 corrects for sample-size bias and is less upwardly biased than ηp^2. For interpretation, we apply Cohen's (1988) benchmarks originally proposed for ηp^2**:** 0.01 = small, 0.06 = medium, 0.14 = large**.**

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

sector-specific nuances in innovation prioritization may exist – particularly in education-related and technical fields.

B) Management Competences

For management competences, no significant differences across sectors were found ($F(6,143) = 0.31$, $p = .929$, $\eta p^2 = .013$, $\omega^2 \approx .000$). All groups rated this domain as important, with minor variation (range: M = 3.94–4.27). These results reflect a broad consensus on the foundational role of management skills in technician training – independent of sectoral context or organizational type.

C) Green Transformation Competences

Perceptions of green transformation competences also showed **no statistically significant differences** between sectors ($F(6,143) = 1.20$, $p = .309$, $\eta p^2 = .048$, $\omega^2 = .008$). However, the descriptive statistics indicate slightly higher ratings in the **Services & Consulting (M = 4.38)** and **Others (M = 4.10)** sectors, compared to **ICT & Digitalization (M = 3.69)** or **Agriculture & Environment (M = 3.69)** – a finding that appears counterintuitive, especially in the case of Agriculture & Environment – highlighting a potential gap between thematic relevance and perceived operational importance.

D) Digital Competences

Similarly, digital competences were perceived as **equally important across all sectors** ($F(6,143) = 0.82$, $p = .558$, $\eta p^2 = .033$, $\omega^2 \approx .000$). The highest values appeared in **ICT & Digitalization (M = 4.62)** and **Others (M = 4.56)**, whereas **Agriculture & Environment (M = 4.13)** rated digital skills slightly lower. Despite minor differences in mean ratings – particularly between digital-native sectors and more traditional domains – the results do not indicate any statistically significant sectoral divergence in the perceived importance of digital skills.

Conclusion on Sectoral Variation in Future Skill Perceptions

To provide an accessible comparison of sectoral priorities, the following table summarizes the mean relevance ratings for each Future Skill domain by industry category, based on the general importance questions (Overall Innovation, Overall Management, Overall Green Transformation, Overall Digital).

This cross-sectoral perspective complements the ANOVA analysis and helps to identify subtle contextual shifts in emphasis, particularly regarding innovation and green transformation competences.

Table 7: Mean Ratings of Future Skill Domains by Sector (Descriptive Overview of ANOVA Results)

Sector	Innovation	Management	Green Transformation	Digital
Manufacturing & Industry	4.20	4.06	3.88	4.35
ICT & Digitalization	4.33	4.00	3.69	4.62
Construction & Engineering	4.52	4.27	3.81	4.39
Education, Research & Health	4.52	4.11	3.97	4.39
Agriculture & Environment	4.00	3.94	3.69	4.13
Services & Consulting	4.00	4.13	4.38	4.44
Other	4.10	4.10	4.10	4.56

Across all domains, sectoral differences in perceived importance were minimal or statistically non-significant. The only marginal variation appeared in the Innovation Competence domain. These findings suggest that Future Skills are widely regarded as strategically relevant regardless of industry context, though specific emphasis may vary slightly between sectors – especially in relation to innovation and sustainability.

In sum, while the transversal nature of core competences is reaffirmed, small sector-specific deviations should be taken into account to fine-tune curricula. Sector-sensitive training designs may increase resonance and implementation efficiency – without undermining the overall coherence of a unified Future Skills framework.

These analyses will feed into the refinement of the final competence map in Section 5.1

4.2.4 Company Size Differences in the Perceived Importance of Future Skill Domains (Based on Overall Ratings) (EU)

To explore potential differences in competence perception by company size, participating organizations were grouped into four categories based on the number of employees:

1. Micro (1–9 employees)
2. Small (10–49 employees)
3. Medium-sized (50–249 employees)
4. Large (250+ employees)

The analysis focused on the overall domain ratings (Innovation, Management, Green Transformation, Digital) and used univariate ANOVA to test for statistically significant differences.

Tables 8–11 display the mean relevance ratings, standard deviations, and sample sizes for all four Future Skill domains—**Innovation**, **Management**, **Green Transformation**, and **Digital**—differentiated by company size (micro, small, medium, large). The data provide a comparative overview of how organisations of different sizes assess the perceived importance of each domain.

A) Innovation Competences

A univariate ANOVA revealed no statistically significant differences across company sizes in the perceived importance of innovation competences ($F(3,146) = 0.39$, $p = .763$, $\eta p^2 = .008$).

Table 8: Mean Ratings of Innovation Competences by Company Size

Company Size	Mean	Standard Deviation	Number of respondents
Micro (1–9)	4.50	0.753	46
Small (10–49)	4.35	0.596	17
Medium (50–249)	4.30	0.651	30
Large (250+)	4.44	0.945	57

All groups showed high appreciation for innovation skills. The lack of significant differences suggests a broad consensus across firm sizes.

B) Management Competences

The ANOVA showed statistically significant but small differences between groups ($F(3,146) = 2.74$, $p = .046$, $\eta p^2 = .053$). Micro enterprises rated management competences higher ($M = 4.37$), while medium-sized companies rated them lower ($M = 3.93$).

Table 9: Mean Ratings of Management Competences by Company Size

Company Size	Mean	Standard Deviation	Number of respondents
Micro (1–9)	4.37	0.741	46
Small (10–49)	4.24	0.562	17
Medium (50–249)	3.93	0.916	30
Large (250+)	4.14	0.810	57

These findings indicate that smaller organizations may place greater emphasis on project and quality management as critical tools for efficiency and coordination.

C) Green Transformation Competences

The analysis did not reveal statistically significant differences in the perception of green transformation skills across company sizes ($F(3,146) = 1.92$, $p = .129$, $\eta p^2 = .038$).

Table 10: Mean Ratings of Green Transformation Competences by Company Size

Company Size	Mean	Standard Deviation	Number of respondents
Micro (1–9)	3.87	1.067	46
Small (10–49)	4.12	0.781	17

Medium (50–249)	3.67	0.959	30
Large (250+)	4.14	0.895	57

Although no significant effect was found, medium-sized firms rated green skills slightly lower on average, potentially due to practical implementation constraints or resource limitations.

D) Digital Competences

No significant group differences were observed regarding digital competences either ($F(3,146) = 1.83$, $p = .145$, $\eta p^2 = .036$).

Table 11 Mean Ratings of Digital Competences by Company Size

Company Size	Mean	Standard Deviation	Number of respondents
Micro (1–9)	4.65	0.604	46
Small (10–49)	4.41	0.577	17
Medium (50–249)	4.40	0.770	30
Large (250+)	4.32	0.869	57

Micro-enterprises rated digital skills highest, which may reflect their stronger need for digital agility, lean communication, or remote processes.

Conclusion on Company Size Variation in Future Skill Perceptions

Across all domains, perceived importance of Future Skills was high regardless of company size.

- Only **management competences** showed statistically significant variation (small effect size), with smaller firms placing greater importance on them.
- In other domains, particularly **innovation** and **digital skills**, descriptive trends were visible but not statistically significant.

While minor differences exist, Future Skills are broadly recognized as relevant across company sizes. This supports the idea of **shared transformation challenges**, although training offers may benefit from tailored emphasis in small vs. large enterprise contexts.

Note: ηp^2 values represent effect sizes from the ANOVA. According to Cohen (1988), ηp^2 values of 0.01 = small effect, 0.06 = medium effect, 0.14 = large effect.

These analyses will feed into the refinement of the final competence map in Section 5.1.

4.2.5 Conclusion and Strategic Priorities for Future Technician Training

The combined results of the descriptive and correlational analyses reveal both areas of consensus and divergence in stakeholder expectations regarding technician competences at EQF Levels 5–6. While all surveyed sub-competences were rated as important (M > 3.8), the relevance matrix – calculated via Pearson correlation with each domain's overall importance rating – uncovers meaningful differences in strategic alignment.

Some competences, such as **Creative Problem-Solving** (M = 4.57, r = .40) and **Digital Fundamentals** (M = 4.37, r = .63), emerge as core transversal skills with both high perceived relevance and strong statistical correlation. Others, such as **Cloud-Based Manufacturing** (M = 3.84, r = .28) or **Sustainable System Design** (M = 3.94, r = .52), show weaker alignment—suggesting either early-stage recognition or conceptual ambiguity. Notably, **Sustainability Thinking** (M = 3.93, r = .71) and **Research-Driven** (M = 4.07, r = .50) rank among the most strategically aligned but comparatively undervalued competences.

These patterns reflect a key challenge: stakeholder expectations about future competence needs do not always match the internal strategic structure of competence domains. This highlights the need for a more **deliberate alignment between perceived importance and actual transformation potential**, especially in the design of technician training architectures.

Importantly, **all sub-competences included in the survey were rated as relevant**. The differences lie not in absolute importance, but in how **strongly each competence correlates with strategic domain goals**. As survey participants were not individually identified by role or institution type, the analyses reflect statistical trends – not categorical judgments.

Table 12 summarizes the most strategically aligned and high-correlation competences per domain, as identified through stakeholder relevance ratings and their statistical correlation with domain-level constructs. These competences constitute core curricular priorities for technician training at EQF Levels 5–6.

Table 12: Priority Competences for Curriculum Integration by Domain and Strategic Role

Domain	Competence	Justification
Innovation	Creative Problem-Solving (FS-01)	Core competence with highest importance and correlation
	Applied Innovation Research (FS-02)	Hidden potential; strongly predictive of innovation capability
	Responsible Research Practice (FS-03)	Hidden potential; foundational for responsible innovation

Domain	Competence	Justification
Management	Project Leadership (FS-09)	Core competence; critical for task coordination and innovation execution
	Research-Driven (FS-10)	Hidden potential; enables structured innovation processes
Green Transformation	Sustainability Thinking (FS-14)	Core competence; broad consensus across stakeholders
	Systems Thinking (FS-15)	Hidden potential; crucial for integrating complexity and lifecycle thinking
Digital	Digital Fundamentals (FS-17)	Core digital foundation; highest correlation in all domains
	Data Literacy (FS-18)	Core; supports evidence-based work and smart manufacturing
	AI-Literacy & Application (FS-20)	Core digital frontier skill; increasingly indispensable

Implication: These competences should be considered core curricular pillars for future-proof technician education at EQF Levels 5–6.

A future-ready technical curriculum should emphasize:

- **Integrated innovation literacy**: Creativity, Design, Responsibility
- **Operational mastery**: Project and Research Design
- **Green complexity navigation**: Sustainability Thinking and Systems Thinking
- **Digital fluency**: Fundamentals, Data Literacy, and AI-Literacy & Application

Transversal skills such as communication, collaboration, and cybersecurity should be embedded across all modules – unless sector-specific needs (as illustrated in Chapter 5.2) demand deeper integration.

Ultimately, EQF Level 5–6 technicians should not only be equipped to navigate change – but to actively shape Europe's innovation and sustainability agendas across industrial ecosystems.

4.3 Expert Interviews of Future Skill Demand

To complement and triangulate the findings from the desk research and the quantitative survey, a qualitative research strand was conducted based on twelve stakeholder interviews. All interviews were carried out with experts from industrial companies across five European countries: **Italy, France, Germany, Poland, and the United Kingdom**.

In some cases, multiple stakeholders were interviewed jointly, yet each participating company provided a distinct institutional perspective. For analytical purposes, these are treated as separate units of analysis, resulting in twelve individual company contributions.

The aim of this qualitative inquiry was to gain **practitioner-based insights into evolving competence requirements** for mid-level technicians working in **research-, innovation- and transformation-oriented industrial environments**. The interview findings served to **contextualize the survey results** and to ensure that the HUCO Labs Future Skills Framework is not only theoretically grounded, but also aligned with real-world industrial practices.

Overview of Participants

The twelve participating organizations represent a diverse cross-section of European industry – ranging from **small-cap manufacturers** to **mid-sized enterprises**, **global suppliers**, and **specialized technology providers**. While many operate in industrial production and engineering, additional domains include **digital services**, **pharmaceutical manufacturing**, and **infrastructure systems**.

The sample includes companies from the following sectors:

- Automotive engineering and supply
- Biomedical and pharmaceutical manufacturing
- Digital transformation and IT services
- Component and mechanical manufacturing
- Industrial automation and systems integration
- Engineering consulting and applied R&D services

The organizations included representatives from both traditional industrial fields and innovation-driven environments, allowing for nuanced insights into the evolving skills needs of mid-level technicians in the context of green and digital transformation.

Key Themes Identified

The analysis of interviews conducted with industrial experts from twelve European companies across five countries reveals a clear prioritization of specific competences required for mid-level technicians. These professionals are increasingly expected to take on hybrid roles within digitalized, automated, and sustainability-driven production environments.

The interviews uncovered several recurring competence domains, which are detailed in the following sections

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

4.3.1 Technical Future Skill Priorities for Mid-Level Technicians

A) Digitalization and Data Literacy

Technicians must be able to work confidently with digital systems, analyze data sources, and apply digital tools such as AI-based assistance systems (e.g., ChatGPT) in a reflective and critical manner. This includes:

- Data cleaning, analysis, and interpretation
- Foundational knowledge of IT systems and their integration
- Critical use of automation and AI tools

B) Automation, Robotics, and Mechatronics

The ability to operate, maintain, and improve automated systems was emphasized in nearly all interviews. In particular:

- Knowledge of automation and robotics
- Mechatronic system integration (mechanics, electronics, software)
- Additive manufacturing (3D printing)

C) Maintenance & Industry 4.0

Technical maintenance is evolving toward data-driven processes. Required competences include:

- Industrial Maintenance 4.0
- Use and design of Human-Machine Interfaces (HMI)
- Condition-based diagnostics and monitoring systems

D) Security & Connectivity

In a highly connected production environment, cybersecurity and IoT literacy are indispensable:

- Cybersecurity for industrial systems
- Handling of IoT devices in production settings
- Risk detection and mitigation in operational environments

E) Design & Simulation

Modern product development demands a strong command of digital design and analysis tools:

- CAD/CAE skills
- Simulation of technical systems and processes
- Design-for-X and concurrent engineering

F) Sustainability & Green Technologies

Technicians must be capable of applying sustainable technologies and understanding their economic implications. Highlighted were:

- Solar technology, heat pumps, and insulation systems
- Evaluation of energy efficiency and return on investment
- Environmental impact assessment of technical decisions

G) Applied Research & Development

Several interviewees pointed to deficits in applied research capabilities. As a result, the following skills are seen as priorities:

- Prototyping and iterative testing
- Documentation and analysis of results
- Understanding of the research cycle and applied experimentation

H) Statistical Methods & Process Optimization

For quality management and technical process improvement, technicians need:

- Application of statistical methods
- Lean and Six Sigma principles
- Data-driven process improvement approaches (e.g., Kaizen)

Conclusion

The interviews conducted across multiple European stakeholders revealed a clear set of technical priority areas essential for the future readiness of mid-level technicians. These include digitalization and data literacy, automation and mechatronics, and modern approaches to maintenance aligned with Industry 4.0. Proficiency in cybersecurity and IoT, along with competences in digital design, simulation, and sustainable technologies, were consistently highlighted. Additionally, the need for applied research capabilities, prototyping skills, and understanding of iterative development cycles emerged as key gaps in current training systems. Finally, strong command of statistical methods and data-driven process optimization techniques – such as Lean, Six Sigma, and Kaizen – round out the profile of future-proof technical expertise. These competencies reflect the increasing complexity and interdisciplinarity of industrial work environments, demanding hybrid, digitally fluent, and sustainability-aware technician profiles.

4.3.2 Transversal Future Skill Priorities for Mid-Level Technicians

Alongside technical proficiency, all interviews emphasized the equal importance of transversal competencies for mid-level technicians. These cross-functional skills are essential for enabling innovation, ensuring workplace resilience, and fostering adaptability in increasingly dynamic, interdisciplinary environments.

The key transversal skills identified are as follows:

A) Problem-Solving and Root Cause Analysis

Technicians are expected to not only fix issues but to understand their origin. Structured problem-solving, often aligned with Lean or Six Sigma methods, was a consistently named priority.

B) Adaptability and Flexibility

In fast-evolving industrial settings, the ability to adapt to new technologies, processes, and organizational demands was viewed as essential. Flexibility in roles, tools, and environments was repeatedly emphasized.

C) Self-Directed Learning and Lifelong Learning

Many interviewees criticized traditional training as too passive. Future technicians must take initiative in their own learning, build self-initiated projects, and cultivate the ability to “learn how to learn.

D) Communication and Collaboration

Technicians must be effective communicators, particularly in interdisciplinary and sometimes remote teams. Beyond task execution, contributing to shared goals and knowledge exchange was stressed.

E) Creativity and Proactive Mindset

Beyond following instructions, technicians should develop and propose solutions, actively contribute to innovation processes, and continuously look for improvements within existing toolsets.

F) Ownership and Responsibility

Technicians are expected to take full responsibility for their tasks and understand the broader impact of their decisions on the production system and organizational goals.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

G) Entrepreneurial and Systemic Thinking

Interviewees emphasized the need for technicians to understand their role within the company as a whole – economically, strategically, and ecologically.

H) Interdisciplinary Literacy

Working across boundaries is essential: understanding the perspectives and “languages” of engineers, business professionals, or sustainability experts is considered a key enabling skill.

I) Resilience and Readiness for Change

A mindset of continuous adaptation, openness to transformation, and emotional resilience in the face of uncertainty is increasingly necessary in complex production environments.

Conclusion

The interview findings point to a paradigm shift in how we define the technician profession. Beyond mastering tools and technologies, tomorrow’s mid-level technicians must be **adaptive, creative, communicative, and resilient** – ready to co-create innovation in both digital and green transitions.

4.3.3 Gaps in Current Training Programs

The interview data reveals a consistent critique of existing training programs for mid-level technicians. While foundational technical knowledge is often provided, the current systems fall short in several key areas that are critical for preparing technicians for future roles in digitalized, automated, and sustainability-driven industries.

A) Lack of Practical Application

Many interviewees emphasized that current programs are overly theoretical and fail to reflect the realities of industrial practice. There is insufficient opportunity for hands-on learning, real problem-solving, and exposure to authentic work environments.

B) Insufficient Research & Innovation Skills

Technicians are not adequately trained in applied research and development. Skills such as prototyping, iterative testing, experimental documentation, and analytical reflection are rarely included, despite being essential for innovation-driven industries.

C) Gaps in Digital and AI Literacy

While basic digital skills are often present, there is a noticeable lack of advanced digital literacy. This includes data analysis, the effective use of AI tools, and an understanding of digital systems beyond surface-level functionality. Several interviewees noted that AI tools are often used passively – "like a search engine" – without awareness of data privacy, biases, or strategic application.

D) Weak Interdisciplinary Integration

Current curricula are largely siloed, separating mechanical, electrical, software, and sustainability domains. The ability to integrate knowledge across these fields is rarely taught, although it is essential in Industry 4.0 and green transformation contexts.

E) Deficit in Self-Learning and Autonomy

A strong reliance on guided instruction persists in many training settings. Interviewees observed that trainees often lack the initiative and confidence to learn independently, solve problems without step-by-step guidance, or engage in self-initiated technical projects.

F) Limited Development of Soft Skills

Communication, collaboration, and team interaction skills – especially in interdisciplinary or multicultural settings – are insufficiently addressed. These competencies are critical for working in modern, agile production environments.

G) Missing Economic and Sustainability Perspectives

The integration of economic reasoning (e.g., cost-benefit analysis, ROI of green technologies) and ecological responsibility is still underdeveloped. Technicians are often not trained to assess or communicate the financial and environmental impacts of their technical decisions.

Conclusion

Current training programs do not yet equip mid-level technicians with the full skillset required to actively contribute to digital and sustainable innovation. Bridging the gap between formal curricula and workplace realities requires stronger integration of practice, research, autonomy, digital depth, and systemic thinking.

4.3.4 Recommendations for Further Training

The qualitative interviews identified several key areas where training programs for mid-level technicians must evolve in order to meet the demands of green and digital transformation. These recommendations are based on recurrent themes across multiple stakeholders and highlight not only technical training needs but also structural and pedagogical improvements.

A) Strengthen Practical and Project-Based Learning

Stakeholders across countries emphasized the insufficient practical exposure in current programs. Sandwich models, real-life projects, and interdisciplinary teamwork were seen as essential to prepare technicians for innovation tasks.

Recommended Actions:

- Integrate internships and apprenticeships more systematically
- Use company-based challenges to structure applied learning
- Encourage feedback culture and self-evaluation

B) Embed Applied R&D and Prototyping Competencies

Technicians are currently underprepared for research-related responsibilities. Skills such as iterative testing, documenting experiments, and evaluating outcomes must be built into training.

Recommended Actions:

- Include structured prototyping labs and research cycles
- Train on hypothesis building, testing, and analysis

C) Advance Data and AI Literacy with Critical Thinking

Training in digital tools remains superficial. Stakeholders stressed the importance of teaching technicians how to critically assess and apply data, AI systems, and automation tools.

Recommended Actions:

- Train how to clean, interpret, and validate data
- Develop AI-critical thinking (e.g., bias, data privacy, tool limits)

D) Foster Continuous Improvement Methods and Process Thinking

Lean, Six Sigma, and Kaizen are seen as essential mindsets and methods, not only for process optimization but also for fostering innovation and accountability.

Recommended Actions:

- Integrate Lean/Agile into project work
- Teach root-cause analysis and structured problem-solving

E) Promote Hybrid and Interdisciplinary Competence Profiles

A recurring recommendation was to break down the silos between mechanical, digital, and ecological domains. Hybrid profiles allow technicians to understand and act across disciplines.

Recommended Actions:

- Develop training modules that combine digital, mechanical, and sustainability themes
- Facilitate interdisciplinary projects (e.g., mechanics + data + green tech)

F) Build Economic and Sustainability Thinking

Technicians must understand the economic and ecological impact of their actions. This includes cost-benefit thinking for energy efficiency or green investments.

Recommended Actions:

- Train in ROI calculation for green tech
- Use lifecycle thinking (LCA) and sustainability metrics

G) Support Self-Directed Learning and Ownership

Current trainees often lack autonomy. Teaching how to independently research, evaluate, and implement solutions is seen as crucial for both technical and personal development.

Recommended Actions:

- Integrate self-driven problem-solving projects
- Teach “learning-to-learn” as a formal competence

H) Strengthen Communication and Collaboration in Teams

Effective collaboration – particularly across functions and disciplines – is still insufficiently trained. Several interviewees demanded more structured team and reporting exercises.

Recommended Actions:

- Include interdisciplinary team tasks
- Train documentation, reporting, and communication tools (e.g., collaborative platforms)

Conclusion

The interviews show a clear need to modernize technician training. Future programs must foster **practical experience, hybrid profiles, interdisciplinary skills, data competence, and**

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

economic responsibility. These transformations require a shift not only in content, but also in **pedagogical philosophy**, **industry integration**, and **institutional collaboration**.

4.3.5 Importance of Industry-Academia Collaboration

A recurring theme across all interview partners was the pivotal role that collaboration between industry and academic institutions plays in the effective training of mid-level technicians. Especially in the context of digital and green transformation, this partnership is considered not optional, but essential.

A) Bridging the Theory-Practice Gap

Many interviewees noted a persistent disconnect between academic curricula and the realities of industrial workplaces. Academic training often remains abstract, while real-world problem-solving, prototyping, and system-level thinking are underrepresented.

Recommendation: Embed real-world challenges and workplace-based projects directly into curricula to ensure relevance.

B) Learning Under Real Constraints

Working with industrial partners exposes students to authentic timelines, expectations, and consequences. This builds professional responsibility and deepens learning. Several experts emphasized that only under real conditions can learners truly develop autonomy and applied judgment.

C) Mutual Benefit for Institutions and Companies

Interviewees agreed that industry-academia collaboration is not a one-sided service, but a symbiotic relationship. Companies benefit from early access to talent and ideas, while institutions gain relevance and adaptivity.

D) Interdisciplinary Project Mode as the Gold Standard

Several interviews emphasized that the most effective form of collaboration is structured around **real interdisciplinary projects** that combine technical, economic, and ecological perspectives – ideally co-supervised by academic and industrial mentors.

E) Cultural Learning and Identity Formation

Early contact with industry was also seen as vital for developing a sense of professional identity, responsibility, and adaptability. This cultural socialization cannot be taught in the classroom alone.

Conclusion

Industry-academia collaboration is not merely a useful add-on – it is a **structural requirement** for ensuring the relevance, depth, and practical applicability of technician training in the 21st century. Real-world co-designed projects, mutual feedback loops, and a shared vision of skill development are the cornerstones of a future-ready vocational ecosystem.

4.3.6 Reflection on Existing Competence Frameworks

Across interviews with European industry and education experts, there was broad agreement that existing competence frameworks – such as those addressing Research, Development & Innovation (RDI), Green Transformation, and Digital Transformation – generally reflect relevant strategic priorities, but fail to translate into practical, technician-level outcomes.

While EU-level frameworks were viewed positively in principle, a clear disconnect was noted between high-level policy goals and technician-level operational skills. Interviewees described the promoted skills as often too abstract, failing to reflect the hybrid, hands-on competence combinations required in SME practice. There is a strong need for more granular and practice-oriented competence definitions that better support technician-level implementation.

A) Frameworks are too abstract and not technician-oriented

Multiple interviewees emphasized that current frameworks are conceptually sound but often too high-level. They lack translation into the **operational hybrid skill sets** that mid-level technicians need in real industrial contexts.

B) Hands-on, hybrid, and cross-domain competences are missing

Respondents criticized those current models remain **siloed** (e.g., separate tracks for green or digital skills) and fail to **interlink domains** like mechanical engineering, software, and sustainability.

C) Mismatch between framework design and workplace demands

Technicians are often expected to work flexibly across departments and disciplines, while frameworks assume more linear career paths and clearly segmented roles.

D) Need for contextualized adaptation per sector

Frameworks are sometimes too generic. Sector-specific nuances (e.g., metalworking vs. IT logistics) are not sufficiently addressed, despite partially transferable baseline skills.

E) Practical implementation gaps in training design

Even when frameworks are used as a reference, the actual implementation in training curricula remains often theoretical or overly fragmented.

Conclusion

While current competence frameworks are **strategically well-aligned**, they **lack operationalization**. To make them effective, they must be:

- **Translated into modular, hybrid curricula**
- **Adapted to technician-level profiles**
- **Applied through real-world projects in specific industrial contexts**

4.3.7 Sector-Specific Nuances

Based on anonymized interview data from European industry and education stakeholders

While many transversal competences are widely applicable across sectors, the interviews revealed that certain technical skills and focus areas are strongly **sector-dependent**. These sector-specific nuances affect both **skill priorities** and **training design**.

A) Automotive and Biomedical Technology (Large Enterprises[17])

A representative from a large Italian automotive supplier emphasized the growing importance of CAD/CAE and lifecycle-oriented engineering in their design processes. Similarly, a biomedical manufacturing expert from a European OEM reported increasing reliance on simulation tools and AI-based process modeling.

Sector-specific focus areas:

- CAD/CAE and simulation tools
- Artificial intelligence for modeling and process control
- Lifecycle assessment (LCA)
- “Design for X” and second-life product thinking

B) Component Manufacturing (Medium-Sized Enterprise)

A managing director from a UK-based small plastics manufacturing company emphasized that modernizing existing production lines – rather than full-scale technological replacements – is often the most feasible and impactful innovation strategy. Key competence needs include the ability to identify inefficiencies in legacy systems and calculate the ROI of energy-saving upgrades.

[17] This section summarizes anonymized insights from two separate interviews conducted with large firms in the automotive and biomedical sectors.

Sector-specific focus areas:

- Identification of energy-saving potential in legacy systems
- Implementation of electric motor upgrades
- Understanding insulation, solar integration, and cost-efficiency

C) Energy and Utilities (Large Enterprise)

A technical director from a large European company specializing in energy infrastructure emphasized the need for technicians to operate across mechanical, digital, and process engineering interfaces. Key priorities included cybersecurity for cyber-physical systems, interoperability of human-machine interfaces (HMI), and competence in IoT-based monitoring and control systems.

Sector-specific focus areas:

- Security of cyber-physical systems in critical infrastructure
- Human-machine interface (HMI) design
- Integration of mechanical, process, and digital technologies

D) Digital Logistics and Industrial IT (Medium-Sized Enterprise)

A digitalization lead from a German logistics-focused IT company emphasized that technicians do not require deep programming skills, but rather sector-specific system knowledge, applied digital fluency, and the autonomy to troubleshoot and solve domain-relevant issues.

Sector-specific focus areas:

- Integration of IT systems in logistics workflows
- Data architecture and platform knowledge
- Autonomous troubleshooting and system ownership

E) Cross-Sectoral Insight: Transferability Requires Contextualization

While foundational competencies like **data literacy**, **problem-solving**, and **green awareness** are transferable, their **implementation varies greatly by sector**. Interviewees called for **modular training frameworks** that allow for sector-specific customization.

Conclusion

Training frameworks should embrace **sector-specific tuning**. Although the core of digital and green skills is shared, their **expression, tools, and operational relevance** must be tailored to sectoral contexts – whether in automotive, logistics, energy, or manufacturing. Only then can hybrid competence profiles become effective in real-world practice.

Co-funded by
the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

4.3.8 Specific R&D-Related Needs Identified by Companies

The following synthesis distills R&D-specific insights from previous sections into a consolidated skill map aligned with real-world innovation tasks.

The qualitative interviews provided deep insights into the evolving requirements for mid-level technicians working in research and development (R&D)-oriented environments. Across all sectors, there was a strong and consistent emphasis on **practice-oriented, technology-driven, and innovation-supportive competences**. These are not only critical for improving operational efficiency but also for enabling technicians to contribute meaningfully to agile innovation processes.

A) Strengthening research competences at mid-level qualification

Companies highlighted the growing need for technicians to assume responsibility in small-scale research activities and contribute to applied R&D tasks. Required competences include:

- Formulating hypotheses
- Conducting structured experiments
- Developing and testing prototypes
- Designing and implementing testing procedures
- Interpreting and communicating research findings

Such skills are still underrepresented in standard vocational curricula and typically acquired informally through work-based learning.

B) Integration of digital technologies into R&D processes

Organizations increasingly expect technicians to integrate digital tools across the entire R&D cycle. This includes:

- Utilizing **CAD/CAE software** for design optimization
- Applying **AI-assisted modeling** and **data-driven decision-making**
- Implementing **automated testing and process simulations**

The shift from manual to digital workflows requires not only technical proficiency but also the ability to critically evaluate digital tool outputs in real-time industrial contexts.

C) Sustainability as a driver for innovation

Sustainability is no longer treated as a downstream add-on but as a core innovation principle. Companies reported a strong need for:

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

- Lifecycle thinking from the early design stages
- Integration of **resource efficiency**, **recyclability**, and **environmental compliance** into development processes
- Understanding of tools like **Life Cycle Assessment (LCA)** and sustainability indicators

Such skills are essential for aligning product innovation with EU Green Deal targets and increasing long-term competitiveness.

D) Agility and interdisciplinary problem-solving

As innovation cycles accelerate (e.g., agile development, design sprints), technicians must:

- Adapt quickly across technologies, tools, and domains
- Collaborate across disciplines (e.g., mechanical, electronic, and digital engineering)
- Apply **design thinking** and **systems thinking** in iterative development contexts

The ability to understand adjacent fields and translate problems into cross-functional solutions was seen as a key success factor for innovation-driven companies.

E) Autonomy and proactive innovation contributions

Interviewees reported a growing expectation that technicians move beyond passive task execution and contribute actively to innovation. Desired competences include:

- Autonomous problem identification
- Development of optimization ideas and improvement proposals
- Taking initiative within defined work scopes

Companies emphasized that this shift in mindset must be supported by training environments that foster creativity, responsibility, and experimentation.

F) Enhanced documentation and communication skills

Effective communication of R&D outcomes was viewed as increasingly critical, especially in international or cross-organizational settings. Required competences include:

- Documenting technical processes and test results with precision
- Presenting findings to non-technical stakeholders (e.g., managers, clients)
- Engaging in intercultural communication within distributed innovation teams

Clear, audience-appropriate communication is essential to ensure the visibility and impact of technicians' contributions in complex innovation ecosystems.

The following integrated competence map is the result of a three-step development process. First, Section 4.1 provided a structured extraction of competence items from leading European frameworks. Second, these initial descriptions were empirically validated and reprioritized through the quantitative relevance analysis (Section 4.2) and qualitative interview findings (Section 4.3). Finally, the insights from all sources were synthesized into a refined and operational competence model. This integrative approach ensures conceptual continuity, empirical robustness, and practical applicability for curriculum and training design at EQF Levels 5 and 6.

Conclusion

The qualitative interviews underscore a fundamental shift in the role of mid-level technicians: they are no longer expected to merely execute predefined tasks, but to actively engage in applied research, development, and innovation. Across all sectors, companies emphasized the need for technicians to contribute to experimentation, digital integration, and sustainability-driven product development. However, several persistent gaps in current training systems stand in the way – particularly in applied R&D competences, autonomous work practices, and interdisciplinary collaboration.

Technicians must be equipped to formulate hypotheses, conduct structured testing, and clearly communicate their findings. The ability to work fluently with digital tools – from CAD/CAE systems to AI-assisted modeling – is essential. At the same time, sustainability is becoming a core design principle, requiring competencies in lifecycle thinking, resource efficiency, and environmental impact assessment.

Equally vital are hybrid skills that bridge the technical and communicative spheres: agile collaboration across domains, proactive problem-solving, and the ability to document and reflect on complex work processes. These findings demonstrate that innovation-readiness at the technician level depends on competence profiles that integrate research literacy, digital fluency, ecological awareness, and communicative clarity.

Looking ahead, the challenge lies not only in updating content, but in rethinking pedagogical approaches. Future-oriented training must foster practice-based, integrative learning models that empower technicians to become co-creators in Europe’s green and digital transformation.

One particularly consistent theme throughout the interviews was the need for technicians to manage their own learning, tasks, and priorities independently and proactively. While elements of self-organization and personal responsibility appear in several transversal skills, the qualitative data pointed to a more comprehensive expectation: technicians must structure their own workflows, reflect on progress, and act autonomously within dynamic, multi-tasking environments.

This insight revealed a conceptual gap in the existing competence framework. As a result, a new standalone competence – **FS-13: Self & Time Management Competence** – was added to the **TRIComp Framework**. This competence integrates elements of self-directed learning, task ownership, and reflective time planning, and is further detailed in Chapter 5.1.

4.3.9 Summary of Qualitative Findings

The qualitative interviews conducted with twelve industrial stakeholders across five European countries provide a multidimensional view of the evolving skill requirements for mid-level technicians. The findings reinforce and expand upon the results of the desk research and quantitative survey, while offering grounded insights into the operational realities of innovation-driven companies.

Eight core domains of competence emerged:

A. Technical Future Skills

Technicians must master a broad range of applied technical skills, including digitalization, automation, cybersecurity, simulation, green technologies, and maintenance aligned with Industry 4.0. These are essential for navigating increasingly complex and hybrid production environments.

B. Transversal Competences

Beyond technical proficiency, transversal skills such as problem-solving, adaptability, self-directed learning, communication, collaboration, and interdisciplinary thinking are vital. These competencies enable technicians to act flexibly, responsibly, and innovatively in fast-changing contexts.

C. Gaps in Current Training

Interviewees identified structural weaknesses in existing vocational training systems, including insufficient practice orientation, lack of applied R&D experience, weak integration of sustainability and economic reasoning, and deficits in AI literacy and interdisciplinary synthesis.

D. Recommendations for Training Reform

To address these gaps, stakeholders called for a systemic shift toward project-based learning, hybrid competence modules, integration of real-world challenges, and promotion of self-learning and ownership. Digital and sustainability dimensions must be embedded into the learning architecture.

E. Industry-Academia Collaboration

The interviews highlighted the critical importance of close collaboration between companies and training institutions. Co-designed projects, mutual feedback loops, and real-world application contexts are essential to ensure relevance and innovation-readiness.

F. Critique of Existing Frameworks

While current EU competence frameworks reflect relevant priorities (e.g., green and digital transition), interviewees criticized their lack of operationalization. The promoted skills were seen as too abstract and insufficiently tailored to the technician level.

G. Sector-Specific Nuances

Although many competencies are cross-sectoral, companies emphasized the need for sector-specific tuning. Skill priorities, digital tools, and sustainability strategies vary significantly between sectors such as automotive, energy, logistics, and manufacturing.

H. R&D-Specific Skill Needs

A growing expectation for technicians to actively contribute to applied research and innovation was observed. Required competences include prototyping, AI-supported design, lifecycle thinking, interdisciplinary problem-solving, and documentation of R&D outputs.

In sum, the qualitative evidence calls for a redefinition of the technician role: **from executors to co-creators of innovation**. Technicians must be **prepared to operate autonomously, think systemically, integrate sustainability and digital tools, and collaborate effectively across domains. Training ecosystems must evolve to support this shift – pedagogically, structurally,** and **institutionally**.

As part of this evolution, the analysis also revealed a consistently emphasized transversal requirement: the ability to manage one's own time, tasks, and learning processes with autonomy and foresight. This insight led to the integration of a new competence – **FS-13: Self & Time Management** – into the **TRIComp Framework**, further reinforcing the need for self-directed and reflective professional practice in dynamic work environments.

These findings resonate with what Ulf-Daniel Ehlers has described as the **"drift to self-organisation"** – a concept grounded in extensive research on Future Skills (Eherls, 2020). The present study thus contributes to a growing empirical foundation that positions autonomy, adaptability, and self-directed learning as core enablers of future-ready competence development.

4.4 Summary of Empirical Foundations and Triangulated Findings

This chapter presented the empirical foundations of the HUCO Future Skills Framework, derived from a mixed-methods approach combining desk research, a European-wide stakeholder survey, and expert interviews. Together, these components enabled a triangulated analysis of competence needs for mid-level technicians, ensuring conceptual robustness, relevance, and practical validity.

The **desk research** phase identified and consolidated competence descriptors from leading European frameworks, resulting in an initial structure of 21 Future Skills grouped into four domains: Innovation, Management, Green Transformation, and Digital Competences. This structure served as the analytical starting point for the survey design and guided the thematic coding of interviews.

The **quantitative survey**, conducted across several EU countries, confirmed the general relevance of the proposed competence domains. It provided nuanced prioritizations within each domain and revealed dynamic shifts between current and anticipated future importance. The resulting relevance matrices and correlation analyses offered empirical grounding for refining the competence set and identifying potential gaps.

The **qualitative expert interviews** added depth and contextual insight. They validated core competence areas, highlighted shortcomings in current training systems, and emphasized emerging transversal themes – such as self-directed learning, ownership, and hybrid competence profiles. Notably, the interviews uncovered a recurring demand for technicians to independently manage their own tasks, time, and learning processes.

As a result, the empirical evidence converged around a hybrid competence profile for future technicians – one that blends applied technical skills with transversal capabilities in autonomy, adaptability, innovation, and communication. This triangulation also revealed a conceptual gap in the original framework: the absence of a dedicated competence addressing self- and time management. To address this, a new competence – **FS-13: Self & Time Management** – was integrated as a confirmed competence based on stakeholder feedback, rather than newly invented.

In summary, the empirical analyses confirm the validity of the core Future Skills structure while enriching it through stakeholder-driven insights. The combined findings lay a robust foundation for the framework development presented in Chapter 5, ensuring that the HUCO Future Skills model is both evidence-based and aligned with the evolving realities of European technical professions.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

5 Establishing the TRIComp Framework – Future Skills for Applied Innovation in Technical Professions

Based on the findings of the desk research (Chapter 4.1), the quantitative survey (Chapter 4.2), and the qualitative interviews (Chapter 4.3), a coherent picture emerges:

The future demands placed on mid-level technical professionals are becoming increasingly interdisciplinary, innovation-driven, digitally enabled, and sustainability-oriented.

In response to these findings, this chapter introduces **the TRIComp Framework – Future Skills for Applied Innovation in Technical Professions**. The name **TRIComp** stands for **Transformation, Research, and Innovation Competences**. It refers to a validated set of future-oriented skills that empower mid-level technicians (EQF 5–6) to operate effectively at the interface of applied research, innovation ecosystems, and advanced technical environments.

The TRIComp Framework consolidates the most relevant transversal and domain-specific competences and clusters them into four strategic domains that reflect the evolving role of mid-level technicians in applied research and innovation contexts:

- **Innovation Competences** – driving ideation, research, and early-stage exploration
- **Management Competences** – ensuring implementation, coordination, and quality
- **Green Transformation Competences** – shaping responsible, sustainable transitions
- **Digital Competences** – enabling data-based, automated, and intelligent systems

Each competence is presented in a standardized tabular format including classification (ID, field) and a functional description. The detailed KSA logic (Knowledge, Skills, Attitudes) is not included in the main body of the report but can be found in Annex 9.7. Similarly, exemplary Learning Objectives based on Bloom's revised taxonomy are provided in Annex 9.8. These examples are intended as optional guidance and should be adapted by each Member State or institution according to national priorities, sectoral needs, and contextual requirements.

This structure ensures compatibility with European competence frameworks and transparency in curriculum development.

An overview of the TRIComp Framework is presented in Figure 15 and further elaborated in Chapter 5.1. The model groups 22 validated Future Skills into four strategic competence domains – Innovation, Management, Green Transformation, and Digital – and illustrates their interrelation in the context of applied technical professions. It highlights both domain-specific and transversal competencies relevant to EQF levels 5 and 6.

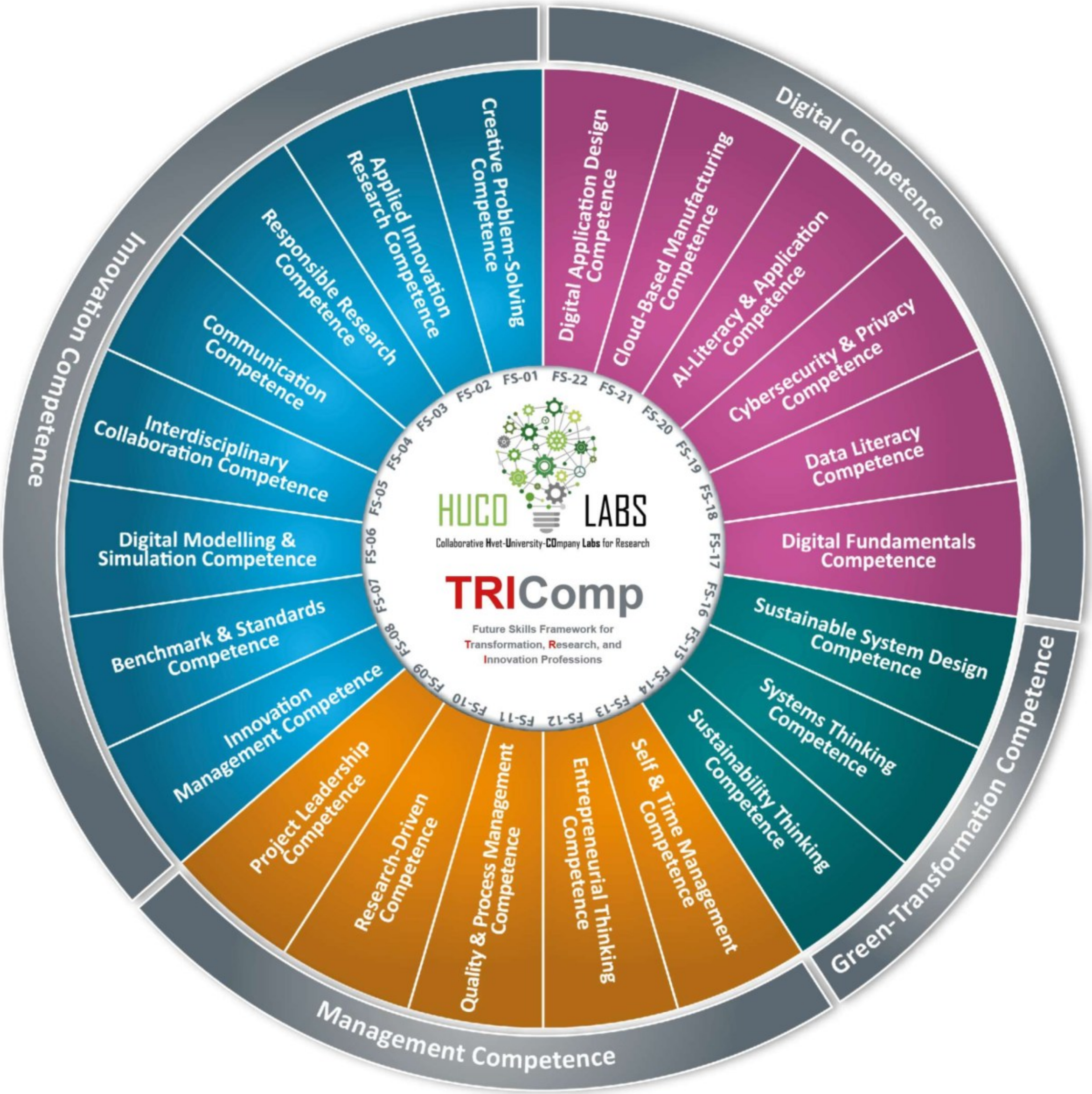

Figure 15: Transformation, Research, and Innovation Competences Framework

Co-funded by the European Union

5.1 Competence Classification and Domain Logic

The **TRIComp Framework** consolidates insights from all empirical and analytical phases of the HUCO Labs project, resulting in a modular, curriculum-oriented competence model for EQF Level 5–6 technical profiles.

It is based on:

- a structured framework comparison (Section 3),
- the prioritization of competences via relevance matrices (Section 4.2.2, Figures 11–14),
- insights from eleven qualitative expert interviews (Section 4.3),
- and role analyses of EQF 5–6 technician functions.

The inclusion of a competence into the map was guided by three criteria:

(1) empirical weight (mean importance and correlation),
(2) conceptual coherence with transformation domains, and
(3) curricular applicability for competence-based learning pathways.

Each competence entry includes:

- a unique ID for cross-referencing,
- a domain classification,
- a title and description,

Based on the results of the empirical analyses, particularly the qualitative interviews, the original competence titles were revised to ensure greater clarity and alignment with actual professional practice. In several cases, the definitions were refined to reflect the functional logic emerging from the data. Furthermore, an additional competence – *Self & Time Management Competence* – was integrated into the framework, as it emerged as a key transversal requirement across multiple domains. Its conceptual foundation draws on the *Future Skills* framework by Ehlers (2020), ensuring both theoretical grounding and practical relevance.

The following table presents the complete set of validated competences within the TRIComp Framework, each with a functional description and domain allocation.

For a more detailed operationalization of each competence, including a structured breakdown by Knowledge, Skills and Attitudes (KSA), as well as didactic learning objectives based on Bloom's revised taxonomy, please refer to Annex 9.7 and 9.8.

These additions provide practical guidance for curriculum development, training design, and learner assessment, aligned with the TRIComp Framework.

Table 13: Description of Competences

ID	Competence Field	Future Skill Name	Description
FS-01	Innovation Competence	**Creative Problem-Solving Competence**	Ability to identify and define practical problems in technical environments and develop feasible, innovative solutions. Includes applying structured methods such as root cause analysis or design thinking, working iteratively, and integrating diverse perspectives. Emphasizes action-orientation, adaptability, and learning from failure in real-world innovation contexts
FS-02	Innovation Competence	**Applied Innovation Research Competence**	Ability to plan and conduct applied research to support innovation in technical and industrial contexts. Includes identifying research questions, using structured experimentation, documenting outcomes, and reflecting on results. Emphasizes the translation of ideas into tested prototypes, integrating feedback and working in interdisciplinary teams.

ID	Competence Field	Future Skill Name	Description
FS-03	Innovation Competence	**Responsible Research Competence**	Ability to conduct research and development activities in a responsible and ethically sound manner. Includes understanding data privacy, acknowledging biases, ensuring transparency, and aligning with societal and environmental values. Supports trust, accountability, and long-term sustainability in innovation processes.
FS-04	Innovation Competence	**Communication Competence**	Ability to clearly express technical information, share ideas, and collaborate across roles and disciplines. Includes verbal, written, and digital communication in work settings, as well as active listening, feedback skills, and intercultural awareness. Supports effective teamwork and knowledge transfer in diverse industrial environments.
FS-05	Innovation Competence	**Interdisciplinary Collaboration Competence**	Ability to work effectively across disciplinary boundaries in technical environments. Includes understanding different expert perspectives, co-developing solutions, and managing knowledge exchange between fields such as mechanics, IT, and sustainability. Emphasizes team integration, mutual respect, and shared problem ownership.
FS-06	Innovation Competence	**Digital Modelling & Simulation Competence**	Ability to use digital tools to design, model, and simulate technical systems and processes. Includes visualizing components, testing alternatives virtually, and supporting decision-making through simulated performance and outcomes. Relevant for iterative development, prototyping, and reducing real-world testing costs.
FS-07	Innovation Competence	**Benchmark & Standards Competence**	Ability to work with benchmarks, industry standards, and technical norms to guide and compare performance. Includes identifying best practices, aligning with quality and safety regulations, and applying reference models to improve processes or innovations. Supports reliability, comparability, and strategic positioning in technical projects.

ID	Competence Field	Future Skill Name	Description
FS-08	Innovation Competence	**Innovation Management Competence**	Ability to plan, structure, and guide innovation processes in technical environments. Includes setting innovation goals, facilitating collaboration across functions, integrating feedback loops, and advancing new ideas from concept to implementation. Supports technicians in contributing to structured innovation within their scope of responsibility.
FS-09	Management Competence	**Project Leadership Competence**	Ability to plan, coordinate, and monitor technical projects in operational environments. Includes defining goals, managing timelines and resources, tracking progress, and facilitating team collaboration. Ensures that innovation and development tasks are completed reliably, efficiently, and in line with strategic priorities.
FS-10	Management Competence	**Research-Driven Competence**	Ability to initiate, support, and shape research-driven processes within technical projects. Includes identifying knowledge gaps, framing research questions, engaging with scientific methods, and integrating findings into applied development. Enables technicians to act as bridges between practice and evidence-based innovation.
FS-11	Management Competence	**Quality & Process Management Competence**	Ability to manage and improve technical processes and quality frameworks in operational environments. Includes planning workflows, applying standards, monitoring performance, and fostering continuous improvement. Enables technicians to align process efficiency with quality assurance and anticipate evolving customer and regulatory requirements.
FS-12	Management Competence	**Entrepreneurial Thinking Competence**	Ability to recognize opportunities, evaluate risks, and contribute to value creation in technical contexts. Includes proposing improvements, understanding business models, and aligning technical work with strategic goals. Encourages technicians to act proactively, cost-aware, and impact-oriented within innovation processes.

ID	Competence Field	Future Skill Name	Description
FS-13	Management Competence	**Self & Time Management Competence**[18]	The competence to reflect on one's own behavior, to structure, plan and control oneself in learning and working processes, to be able to act responsibly and with initiative.
FS-14	Green Transformation Competence	**Sustainability Thinking Competence**	Ability to evaluate the environmental, social, and economic impact of technical decisions. Includes understanding sustainability trade-offs, applying lifecycle thinking, and aligning actions with long-term ecological goals. Fosters responsible innovation and systemic awareness in industrial practice.
FS-15	Green Transformation Competence	**Systems Thinking Competence**	Ability to understand and model complex interrelations between technical, organizational, and ecological systems. Includes recognizing feedback loops, identifying systemic risks, and anticipating unintended consequences of interventions. Essential for navigating complexity in innovation and transformation contexts.
FS-16	Green Transformation Competence	**Sustainable System Design Competence**	Ability to design technical systems with sustainability and lifecycle impact in mind. Includes integrating ecological principles, optimizing for energy and material efficiency, and aligning with environmental standards and user needs. Supports the development of resilient and future-oriented solutions.
FS-17	Digital Competence	**Digital Fundamentals Competence**	Ability to understand and operate basic digital technologies in technical environments. Includes navigating digital interfaces, using standard software and devices, and understanding how digital systems support production and service processes. Serves as the entry point for further development in data, AI, and cybersecurity competences.
FS-18	Digital Competence	**Data Literacy Competence**	Ability to read, interpret, validate, and use data in technical contexts. Includes identifying relevant data sources, detecting errors, drawing meaningful conclusions, and supporting decisions through data-informed reasoning.

[18] ***Ehlers, U.-D. (2019). Future Skills – Future Learning and Higher Education*, p. 48 ff.**

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Field	Future Skill Name	Description
			Forms the basis for quality assurance, process optimization, and evidence-based technical work.
FS-19	Digital Competence	**Cybersecurity & Privacy Competence**	Ability to recognize and mitigate digital risks in industrial and technical settings. Includes basic knowledge of secure system use, data protection principles, and common threats such as phishing, access misuse, or system vulnerabilities. Fosters awareness of responsibility when working with connected systems and sensitive information.
FS-20	Digital Competence	**AI-Literacy & Application Competence**	Ability to understand the principles of artificial intelligence and apply AI tools effectively and responsibly in technical work settings. Includes recognizing opportunities for AI-supported improvement, understanding tool limitations, and using AI to support diagnostics, decision-making, and automation. Fosters critical engagement with AI and promotes informed use in real-world scenarios.
FS-21	Digital Competence	**Cloud-Based Manufacturing Competence**	Ability to understand and work with cloud-based systems used in production environments. Includes connecting machines and digital platforms, monitoring workflows remotely, and using cloud solutions for manufacturing efficiency, flexibility, and scalability. Supports technicians in navigating distributed, data-driven production systems.
FS-22	Digital Competence	**Digital Application Design Competence**	Ability to design and adapt digital solutions for specific technical tasks and workflows. Includes configuring software tools, creating user-friendly interfaces, and tailoring applications to improve efficiency, usability, and system integration. Bridges the gap between digital tools and practical technical needs.

5.2 Cross-Domain Synergies and Functional Roles

While the TRIComp Framework is organized into four analytically distinct domains – Innovation, Management, Green Transformation, and Digital Competences – the triangulated findings of this study point to meaningful functional interdependencies across these domains. These relationships do not stem from statistical correlations alone, but rather from converging qualitative insights (Chapter 4.3), relevance analyses (Chapter 4.2.2), and curriculum design logic. They reflect how competences reinforce each other in real-world learning and work environments and must therefore be considered jointly when designing modular upskilling programs for EQF Levels 5 and 6.

As Professor Ulf-Daniel Ehlers puts it, "**successful action is always the result of multiple competencies working together in context**". This insight underlines the importance of identifying and designing for cross-domain synergies.

Based on expert interviews and the prioritization logic of the relevance matrices, the following cross-domain synergies emerge as particularly critical[19]:

- **Innovation ↔ Digital Competences**

  Digital technologies such as AI, data analytics, and simulation tools act as enablers for applied innovation. For instance, *Creative Problem-Solving Competence (FS-01)* – identified as a core competence in the Innovation domain (r = .40; M = 4.57) – unfolds its full potential only when paired with *AI-Literacy & Application Competence (FS-20)* (r = .53) and Digital Modelling & Simulation Competence *(FS-06)*. While the latter showed lower relevance scores (M = 4.11), qualitative interviews emphasized its emerging value in prototyping, modelling, and iterative refinement in digitally supported R&D environments.

- **Green Transformation ↔ Innovation Competences**

  Systems Thinking Competence (FS-15) and *Sustainability System Design Competence* (FS-14), both high in correlation but moderately rated in perceived importance, represent strategic levers in the Green Transformation domain (r = .65 and .71, respectively). These competences are not merely environmental add-ons; they actively shape eco-innovation practices. Embedding sustainability principles into early-stage R&D (e.g., via *Applied*

[19] The competence labels used in Chapter 5.2 reflect the revised terminology of the updated TRIComp Framework and do not correspond to the original phrasing used in the quantitative survey. This adaptation serves to enhance conceptual clarity and support future work with the data.

Innovation Research Competence (FS-02)) enables life-cycle-oriented and responsible innovation design.

- **Innovation ↔ Management Competences**

Innovation without structured implementation risks fragmentation. Competences like *Project Leadership Competence* (FS-09) (r = .62) *and Research-Driven Competence* (FS-10) (r = .50) are empirically validated as essential for translating creative ideas into tangible solutions. Their curricular integration ensures that innovation efforts are actionable, scalable, and embedded in robust quality assurance processes.

- **Green Transformation ↔ Digital Competences**

Digital skills are increasingly indispensable for enabling green transformation at scale. Competences such as *Digital Fundamentals Competence* (FS-17) *and Data Literacy Competence* (FS-18) provide the technological infrastructure for energy monitoring, process optimization, and resource efficiency. *Although Cloud-Based Manufacturing Competence* (FS-21) scored lowest in relevance and correlation (M = 3.84; r = .28), interviews pointed to its growing importance for distributed, sustainable production models – especially in sectors adopting digital twins and IoT frameworks.

- **Innovation ↔ Entrepreneurial Competence**

While *Entrepreneurial Thinking Competence* (FS-12) received lower quantitative ratings (r = .43; M = 4.02), qualitative interviews underscored its catalytic role in operationalizing innovation – particularly in SME contexts. It acts as a bridge between *Innovation Management* and practical implementation, transforming creativity into value creation and opportunity recognition.

Strategic Implication

These interdependencies illustrate that competence development should not proceed in isolated silos. Instead, **curricula and training programs should adopt a modular structure based on functional competence clusters. These clusters should be sequenced according to cognitive and operational dependencies, ensuring a coherent progression from foundational knowledge to applied innovation capacity.**

5.3 Application in Practice: Persona Illustration[20]: Human-Centered Profiles of Future Technicians

To complement the empirical findings and ensure a human-centered perspective, four exemplary personas were developed. They represent typical profiles of future mid-level technicians working at the intersection of research, development, innovation, and production in advanced manufacturing environments.

The objective is to highlight the **diversity of backgrounds, motivations, skillsets, and future development needs** within the HUCO Labs target group. By illustrating these differentiated profiles, the Future Skill Framework can better align with real-world requirements and the evolving dynamics of technical professions.

The following personas are based on the aggregated results of desk research, quantitative surveys, and qualitative interviews:

5.3.1 Persona 1: Alejandro – The Young Practitioner with a Passion for Innovation

- **Age:** 20 years
- **Origin:** Spain
- **Background:** Recently graduated from vocational training in automation and mechanical engineering. Employed in the automotive industry, focusing on programming, repairing, and maintaining machinery. Possesses mid-level English proficiency.
- **Current Occupation:** Junior Mechatronics Technician (Automotive Sector)
- **Potential Career Path:** Automation Specialist or Digital Production Technician
- **Motivation:** Highly motivated by hands-on work, Alejandro is passionate about driving industrial transformation, particularly in the

[20] All persona illustrations were generated using OpenAI's generative AI tools (ChatGPT/DALL·E).

fields of digitalization and sustainable manufacturing.
- **Current Skills:** Strong digital literacy, solid problem-solving abilities, openness to technological innovation.
- **Future Development Needs:** Deepening expertise in advanced manufacturing technologies, building R&D skills, and enhancing interdisciplinary collaboration capabilities.
- **Strategic Importance:** Represents the new generation of technicians capable of bridging practical application and digital innovation.

5.3.2 Persona 2: Flaus – The Experienced Technician Facing Technological Change

- **Age:** 50 years
- **Origin:** Belgium
- **Background:** Over 20 years of experience in machine assembly and mechanical operations. Holds a secondary or higher education diploma. Facing industry-wide shifts towards automation and digitalization.
- **Current Occupation:** The Experienced Technician Facing Technological Change
- **Potential Career Path:** Smart Factory Technician or Digital Retrofit Specialist
- **Motivation:** Strong drive to adapt and remain professionally relevant. Values stability but shows a growing willingness to engage with new digital and green technologies.
- **Current Skills:** Expert practical knowledge in mechanical assembly and production processes.
- **Future Development Needs:** Acquiring digital competencies, gaining familiarity with Industry 4.0 technologies, and integrating sustainable practices into daily work routines.
- **Strategic Importance:** Illustrates the need for upskilling and lifelong learning pathways for experienced technicians transitioning into digitalized environments.

5.3.3 Persona 3: Nicoletta – The Knowledge Connector between R&D and Operations

- **Age:** 45 years
- **Origin:** Italy
- **Background:** Works at the interface of R&D and operations in the automation and processing sector. Experienced in translating R&D findings into practical process improvements.
- **Current Occupation:** The Knowledge Connector between R&D and Operations
- **Potential Career Path:** Innovation Process Specialist or Applied R&D Technician
- **Motivation:** Seeks to enhance operational efficiency through innovation. Strong commitment to lifelong learning and cross-disciplinary collaboration.
- **Current Skills:** Expertise in automation processes, project management, interdisciplinary communication.
- **Future Development Needs:** Advanced problem-solving, predictive maintenance, emerging technology integration (e.g., AI and IoT).
- **Strategic Importance:** Embodies the emerging role of mid-level technicians as bridges between applied research, innovation, and production systems.

5.3.4 Persona 4: Amina – The Practice-Based Innovator Driving Sustainability

- **Age:** 35 years
- **Origin:** Germany
- **Background:** Combines technical expertise with extensive operational experience. Involved in both manufacturing and design feedback processes. Actively contributes to continuous improvement initiatives.
- **Current Occupation:** Manufacturing Technician with Focus on Continuous Improvement
- **Potential Career Path:** Sustainable Production Specialist or Eco-Innovation Technician
- **Motivation:** Strongly committed to integrating sustainable practices into manufacturing.

Values innovation, teamwork, and cross-functional collaboration.

- **Current Skills:** Advanced digital literacy, strong understanding of sustainable production, critical thinking, effective communication.
- **Future Development Needs:** Building formal R&D skills, expanding interdisciplinary innovation capabilities, deepening knowledge of sustainability-driven design.
- **Strategic Importance:** Represents the type of technician needed to champion sustainability transitions within innovation ecosystems.

5.3.5 Summary of Persona Insights

Together, these four personas illustrate the diverse competence needs and development trajectories of mid-level technicians:

- From young entrants seeking digital and R&D upskilling,
- to experienced practitioners transitioning into digital and sustainable production,
- to interdisciplinary connectors and sustainability-focused innovators.

These profiles provide a human-centered foundation for the design of training programs, modular curricula, and strategic interventions that reflect the real-life contexts of future R&D-oriented technical professionals in Europe.

Building on the competence clusters and their person-centered illustration, the following section reflects critically on the methodological approach of the study. This is essential to ensure transparency, identify limitations, and evaluate the robustness of the TRIComp Framework.

5.4 Conclusion

This ordering reflects the integrated strategic priorities emerging from the HUCO Labs project: **mastering digital transformation, fostering creative and responsible innovation, driving green and sustainable practices, and ensuring effective management of research and innovation processes.**

The integrated competence map is fully aligned with the prioritization logic of the relevance matrices (Figures 11–14) and will serve as the core reference for the design of competence-based curricula and professional development programs within the HUCO Labs project.

6 Methodological Reflection & Action Recommendations

6.1 Critical Review of Methodological Approaches

The TRIComp Framework was developed using a triangulated mixed-methods approach combining:

- **Desk Research** through a Rapid Evidence Assessment (REA),
- **Quantitative Analysis** based on a structured European stakeholder survey, and
- **Qualitative Interviews** with industry, HVET, and R&D actors.

This integrative strategy ensured a robust, multi-perspective foundation for competence identification. However, a critical reflection of each methodological pillar highlights specific strengths and limitations:

6.1.1 Desk Research

Strengths:

- Systematic coverage of state-of-the-art European competence frameworks (e.g., DigComp, GreenComp, NextSkills, AIComp).
- Rigorous synthesis and cross-comparison of competence definitions across innovation, green, digital, and management domains.

Limitations:

- Reliance on existing frameworks may bias results toward currently institutionalized perspectives.
- Emerging domain-specific competences (e.g., hydrogen systems, AI in green micro-grids) were underrepresented in existing framework literature.

6.1.2 Quantitative Study

Strengths:

- High validity through a structured, standardized survey instrument.
- Clear identification of transversal competence priorities via relevance matrices.
- Statistical significance confirmed at the 0.01 level (2-tailed) across all correlations.

Limitations:

- Limited sectoral granularity: sample sizes within specific industries (e.g., biomedical, smart grids) were too small for detailed disaggregation.
- Overrepresentation of technical sectors compared to service innovation contexts.

6.1.3 Qualitative Interviews

Strengths:

- Rich contextual insights into specific competence gaps and R&D-related upskilling needs.
- Grounded validation of survey results through practitioner perspectives.

Limitations:

- Limited geographic spread (focus on Germany, Italy, France, Spain, and Lithuania).
- Potential for interviewee bias toward personally experienced challenges rather than broader structural observations.

6.2 Overall Methodological Robustness

Despite individual limitations, the **triangulation of methods** has significantly enhanced:

- **Internal validity** (coherence across methods),
- **External validity** (alignment with key EU strategies such as the Green Deal, Digital Europe Program, and the EU Pact for Skills),
- **Practical applicability** (real-world alignment with SME, HVET, and innovation ecosystem realities).

The strong mutual reinforcement of results across desk research, quantitative analysis, and qualitative findings underlines the robustness and reliability of the integrated TRIComp Framework.

6.3 Key Lessons Learned for Future Skill Research

Several important methodological lessons emerged:

- **Cross-sectoral comparison is essential:** Future analyses should strengthen disaggregation by sector and innovation domain (e.g., comparing health technology with automotive or energy-focused R&D needs) to better reflect varying competence demands.

- **Increased granularity of competence descriptions is required:** Larger sample sizes and refined analysis will be necessary to capture the functional differentiation of digital and green transformation competences across technician roles and task profiles.
- **Longitudinal validation is critical for framework credibility:** Future research phases should incorporate real-world testing through pilot implementations. This includes tracking individual upskilling pathways, measuring engagement with R&D functions, and assessing competence transfer in applied settings.

6.4 Action Recommendations for Next Phases of HUCO Labs

To ensure the continued success and refinement of the Future Skill Framework, the following next steps are recommended:

1. **Pilot implementation** of the competence framework in selected HVET curricula, enabling iterative testing and refinement of competence descriptions based on real-world practice. The framework can support the design of modular curricula in Erasmus+ Centre of Vocational Excellence (CoVE), GreenComp-based technician programs, and ESF-funded upskilling schemes across Member States.
2. **Sector-specific studies** to further explore variations in skill demand across different innovation-driven industries.
3. **Embed foresight on emerging technologies** (e.g., ethical AI, sustainable computing, bio-based smart materials) into framework evolution.
4. **Integration of European policy updates** (e.g., EU Skills Agenda, Industrial Strategy) into the evolution of the competence model.
5. **Establish continuous stakeholder dialogue mechanisms**, such as competence councils or **feedback loops** within HVET institutions

6.5 Outlook

By critically assessing the methodological path and proactively planning future research and implementation steps, HUCO Labs positions itself at the forefront of competence-based innovation education.
The resulting Future Skills Framework constitutes a modular, evidence-informed, and future-proof instrument to empower mid-level technicians as key enablers of Europe's twin transitions.

Deliverable D2.1 marks a critical milestone in the HUCO Labs project, providing the empirical and conceptual foundation for all subsequent phases of framework validation and implementation.

7 References

Bacigalupo, M., Kampylis, P., Punie, Y., & Van den Brande, G. (2016). *EntreComp: The entrepreneurship competence framework*. Joint Research Centre. https://doi.org/10.2791/593884.

Bianchi, G., Pisiotis, U., & Cabrera Giraldez, M. (2022). *GreenComp: The European sustainability competence framework*. Joint Research Centre. https://data.europa.eu/doi/10.2760/13286

Bourdieu, P. (1986). The Forms of Capital. In: J. Richardson (Ed.), *Handbook of Theory and Research for the Sociology of Education (pp. 241–258)*. Greenwood.

Cinner, J. E., & Barnes, M. L. (2019). Social dimensions of resilience in social-ecological systems. One Earth, 1(1), 51–56. https://doi.org/10.1016/j.oneear.2019.08.003.

Ehlers, U.-D. (2023). *Future Skills 2030: Critical competencies for future workplaces*. NextEducation.

Ehlers, U.-D. (2020). Future Skills: *The Future of Learning and Higher Education*. Springer.

Ehlers, U.-D. (2019). *Future Skills – Future Learning and Higher Education.* Karlsruhe: Baden-Württemberg Cooperative State University.

Ehlers, U.-D. & Eigbrecht, L. (eds.) (2024). Creating the University of the Future. A Global Panorama on Future Skills. Springer. doi: 10.1007/978-3-658-42948-5.

Ehlers, U.-D., Lindner, M., Sommer, S., & Rauch, E. (2023). *AIComp: Future skills for a world increasingly shaped by AI*. NextEducation. https://next-education.org/en/projects/ai-comp.

Erpenbeck, J., & Heyse, V. (2007). *Kompetenzmessung: Zwischenbilanz des Forschungsprogramms*. Waxmann.

Erpenbeck, J., & Sauter, W. (2015). *Kompetenzentwicklung im Netz*. Springer.

ITS Meccatronica Cuccovillo. (2023, Juli). *Courses Catalog – EN version*. https://www.itsmeccatronicapuglia.it/wp-content/uploads/2023/07/Courses-Catalog_EN-version.pdf.

Mulder, M., & Winterton, J. (2017). Competence-based education and training. *Journal of Vocational Education & Training*, 69(1), 1–13.

Rodrigues, M., & Brunner, M. (Eds.). (2020). *Competence framework for applied research in universities of applied sciences*. RECAPHE Project. https://recaphe.eu/project-outputs/.

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The digital competence framework for citizens – With new examples of knowledge, skills and attitudes*. Joint Research Centre. https://data.europa.eu/doi/10.2760/115376.

Vurgun, S. (Ed.). (2020). *Competencies of early-stage researchers: Development of a competency model*. UniWiND – German University Association of Advanced Graduate Education. https://www.uniwind.org/fileadmin/user_upload/Publikationen/2017-UniWiND-Bd6_Englisch_Druck.pdf.

8 Acknowledgements, References & Contact Information

Acknowledgements

We would like to thank all experts, partner institutions, and stakeholders who contributed to the development of this report.

We would like to extend our special thanks to **Jörn Allmann** for his early involvement in the project and for getting the project started in the initial period on behalf of the **NextEducation** research group.

This report was authored by:
Florian Linscheid & Ulf-Daniel Ehlers
Research Group NextEducation
Duale Hochschule Baden-Württemberg, Karlsruhe
Contact: florian.linscheid@dhbw-karlsruhe.de

Citation

Linscheid, F., & Ehlers, U.-D. (2025). *Future Skills for Applied Innovation in Technical Professions – The TRIComp Framework*. Deliverable D2.1 of HUCO Labs – DHBW Karlsruhe.

Disclaimer

Note on AI-Assisted Editing

This report was linguistically and structurally supported by AI-assisted editing (ChatGPT-4), under full human control and expert review. All content, research results, and interpretations were developed by the authors. The AI tool was applied exclusively for linguistic harmonization, terminology consistency, and clarity improvements.

9 Annex

9.1 Field Strategy

The data collection strategy for the HUCO Labs D2.1 report was designed to ensure a comprehensive, multi-stakeholder view on competence demands in research and innovation-oriented work environments. A triangulated mixed-methods approach was applied, combining quantitative survey data, qualitative expert interviews, and desk research.

Quantitative Survey

The quantitative component consisted of an online survey with a total of **150 valid responses** from European stakeholders in vocational and higher education. The target group included educators, training coordinators, industry representatives, and policymakers working with or within EQF Level 5–6 structures. The questionnaire focused on the perceived importance of 25 predefined competences across four strategic domains:

- Innovation
- Management
- Green Transformation
- Digital Competence

Responses were captured using a six-point Likert scale ranging from “Not important” to “Very important”, with an additional "I don’t know" option. The survey was available in English, German, French, Italian, Spanish and Lithuanian.

Qualitative Interviews

To deepen the analysis, a set of **12 expert interviews** was conducted with stakeholders from **Germany, Italy, France, Spain and Lithuania**. The interview partners represented diverse sectors such as **automotive, engineering, ICT, biomedical industries, HVET institutions, and education networks**.

A semi-structured interview guide was used to explore the relevance of selected competences, contextual integration, and implications for training design. Interviewees were selected based on their institutional role and sectoral expertise. Interviews were anonymized, recorded, and partially transcribed for qualitative synthesis.

The combination of quantitative prioritization and qualitative validation enabled a robust identification of priority competences and strategic gaps in the current skill landscape.

9.2 Interview Guideline

HUCO LABS Project: Interview - Future Skills in Technical Professions *(Duration: approx. 20 minutes)*

Introduction:

The HUCO LABS project unites Higher Vocational Education and Training (HVET), universities, and businesses to enhance the skills of mid-level technicians, fostering synergies that drive innovation in the context of the Fourth Industrial Revolution.

Across Europe, the approach to developing Research and Innovation (R&I) skills at EQF Levels 5 and 6 remains fragmented and inconsistent. To address this gap, HUCO LABS will analyze the current landscape and design a standardized training model aimed at equipping technicians with essential R&D competencies. These skills will enable them to collaborate effectively with research teams and entrepreneurs, strengthening their role in innovation processes. The project will test its approach through two pilot training pathways (EQF Level 5 and 6) in advanced manufacturing. The HUCO Labs project, aims to identify key future skills for mid-level technicians to strengthen their capacity for innovation in green and digital transformation. This interview will take about 20 minutes, and your insights will help shape training and education strategies for this workforce.

Questions:

1. *In your opinion, what are the most important future skills that mid-level technicians*

need to successfully contribute to innovation in green and digital transformation?

a. Which technical and non-technical skills are most important? Are there any

gaps you notice?

2. *How well do you think current training programs prepare technicians for research, development, and innovation-related tasks?*

a. Are technicians equipped with sufficient R&D skills in your field?

b. What competencies do they currently lack when engaging in innovation?

3. *What kind of further training or professional development would be most beneficial for mid-level technicians to enhance their skills in digital and green transformation?*

a. Should training focus more on technical, research, or problem-solving skills?

b. Do you see value in interdisciplinary or industry-academia collaboration in

training?

4. *Based on your experience, how well does the existing framework (Research, Development, Innovation, Green Transformation, Digital Transformation) reflect the actual skill demands in your industry?*

a. Any skills that should be added/emphasized?

b. Are there differences in skill requirements across different industries?

5. *Could you briefly describe your role, your company's focus, and how you work with mid-level technicians?*

9.3 Survey Instrument (old labels)

This annex reproduces the original instrument with old labels as fielded; no relabeling or re-aggregation applied.

The survey used for the quantitative analysis comprised the following key sections:

- Introduction and informed consent
- Demographics (country, sector, role, institution type)
- Relevance rating of 25 competences
- Overall evaluation of each strategic domain (Innovation, Management, Green, Digital)
- Open comment section

A six-point Likert scale was used for competences:

1 = Not important
2 = Slightly important
3 = Moderately important
4 = Important
5 = Very important
999 = I don’t know

The questionnaire was implemented in Questback and offered in English. Raw data and SPSS files can be shared with reviewers or project partners upon justified request and under GDPR-compliant conditions. Created with Questback Experience Management

The following section presents the questionnaire:

Future Skills for Research and Innovation in Business

Section 1: Information about your organisation

Please provide general information about your organisation

1) Location of your organisation's headquarters (Country)

2) Company size

- Micro (1-9 employees)
- Small (10-49 employees)
- Medium-sized (50-249 employees)
- Large (250+ employees)

3) Industry in which your organisation primarily operates:

- Manufacturing & Automotive
- Information and Communication Technologies (ICT)
- Construction/Engineering
- Energy & Utilities
- Healthcare & Pharmaceuticals
- Supply Chain, Logistics and Transportation
- Chemistry & Biology
- Process-Optimation
- Financial Services
- Food/Agriculture
- Other

Provide details about the technical workforce in your organisation:

Technicians and associate professionals engage in occupations requiring technical expertise in one or more fields of the physical and life sciences, or the social sciences and humanities. They primarily carry out technical and related tasks associated with research and the application of scientific or artistic principles, operational methods, and relevant government or corporate regulations (in reference to eurostat.eu / ISCO-08)

4) Number of Technicians in your organisation

Section 2: Assessment of necessary Future Skills

In this section, we assess the relevance of various competencies among your employees.

Please provide an answer to the following question:

Which of the following “Future Skills” for technicians do you rate critically important for your organisations' future success? (Timeframe: 2035)

For each competence listed below, please assess its importance.

Part A: Innovation related Future Skills

5) Overall rating: How do you rate the overall importance of Innovation Competences for technicians for your organisations’ future success? (Timeframe: 2035)

Not important Slightly important Moderately important Important Very important I don't know

6) Particular Rating: Which of the following Subskills of the overall "Innovation related Future Skills for technicians" do you rate critically important for your organisations' future success?

Design Research Competence:

[Competence to design and conduct research for innovation, integrating expertise, ethics, and stakeholder collaboration to achieve practical and sustainable solutions.]

Not important Slightly important Moderately important Important Very important I don't know

Ethical Research Competence:

[Competence in conducting research with integrity, ensuring compliance with ethical, legal, identifying biases, evaluating sources, and academic and industry standards while promoting transparency and accountability.]

Not important Slightly important Moderately important Important Very important I don't know

Interdisciplinary Collaboration Competence:

[Competence in integrating multiple disciplines, collaborating across fields, and synthesizing diverse perspectives to develop innovative solutions for complex problems.]

Not important Slightly important Moderately important Important Very important I don't know

Communication competence:

[Competence in clearly communicating research findings to academic and industry audiences, tailoring messages and engaging in scholarly discussions.]

Not important Slightly important Moderately important Important Very important I don't know

Benchmark Orientation Competence:

[Competence in integrating industry best practices and standards into research processes. This includes understanding regulatory frameworks, aligning research models with industrial benchmarks, and ensuring the applicability of findings in professional and industrial contexts.]

Not important Slightly important Moderately important Important Very important I don't know

Creativity & Problem-solving Competence:

[Competence in applying creative methodologies, shifting perspectives, and integrating interdisciplinary insights to develop innovative and effective solutions.]

Not important Slightly important Moderately important Important Very important I don't know

Innovation Management Competence:

[Competence in structuring and managing innovation processes, fostering collaboration, integrating feedback, and advancing ideas from concept to implementation.]

Not important Slightly important Moderately important Important Very important I don't know

Digital Simulation Competence:

[Competence in using digital modeling and simulation to test, refine, and optimize new solutions in industrial and technological contexts.]

Not important Slightly important Moderately important Important Very important I don't know

Part B: Management Competences which enable technicians to successfully conduct research/ innovation projects

14) Overall rating: How do you rate the overall importance of Management Competences for technicians for your organisations' future success? (Timeframe: 2035)

Not important Slightly important Moderately important Important Very important I don't know

15) Particular Rating: Which of the following Subskills of the overall "Management related Future Skills for technicians" do you rate critically important for your organisations' future success?

Project Management Competence:

[Competence in planning and executing development projects in technical and industrial settings autonomously, ensuring effective team coordination, resource management, and alignment with industry and regional needs.]

Not important Slightly important Moderately important Important Very important I don't know

Research-Design-Competence:

[Competence in designing, prototyping, and iteratively testing technical solutions, integrating research methodologies, user feedback, and systematic evaluation to drive innovation.]

Not important Slightly important Moderately important Important Very important I don't know

Quality Management Competence:

[Competence in ensuring compliance with quality standards, applying continuous improvement strategies, and monitoring adherence to industry regulations in product and process development.]

Not important Slightly important Moderately important Important Very important I don't know

Entrepreneurial Competence:

[Competence in identifying market opportunities, evaluating risks, and developing innovative solutions through creativity and strategic decision-making in dynamic environments.]

Not important Slightly important Moderately important Important Very important I don't know

Part C: Competences which enable technicians to lead the green transformation in your organisation

19) Overall rating: How important are green transformation competencies for technicians in ensuring your organization's future success? (Timeframe: 2035)

Not important Slightly important Moderately important Important Very important I don't know

20) Particular Rating: Which of the following Subskills of the overall "Green Transformation related Future Skills for technicians" do you rate critically important for your organisations' future success?

Systems Thinking Competence:

[Competence in evaluating the environmental impact of products and processes, applying systems thinking, and integrating ecological, social, and economic factors for responsible resource management.]

Not important Slightly important Moderately important Important Very important I don't know

Sustainability Competence:

[Knowledge, Skills, Attitudes to apply Circular Economy Strategies in sustainable production and waste management models, fostering systemic change, and designing resource-efficient processes to promote reuse, repair, and recycling.]

Not important Slightly important Moderately important Important Very important I don't know

Systems Design Competence:

[Knowledge, Skills, Attitudes to evaluate and optimize renewable energy systems, ensuring their sustainable application in alignment with ecological and policy frameworks for a just energy transition.]

Not important Slightly important Moderately important Important Very important I don't know

Part D: Digital Competences which enable technicians to develop research and innovation processes

23) Overall rating: How do you rate the overall importance of Digital Competences for technicians for your organisations' future success? (Timeframe: 2035)

Not important Slightly important Moderately important Important Very important I don't know

24) Particular Rating: Which of the following Subskills of the overall "Digital Transformation related Future Skills for technicians" do you rate critically important for your organisations' future success?

Digital Literacy:

[Competence in effectively using digital tools, critically assessing content, managing digital identities, and adapting to evolving technologies while ensuring accessibility, ethics, and agile collaboration in digital transformation.]

Not important Slightly important Moderately important Important Very important I don't know

Cybersecurity Competence:

[Competence in recognizing digital threats, implementing protective measures, and fostering a security-conscious mindset to safeguard data, privacy, and systems.]

Not important Slightly important Moderately important Important Very important I don't know

Data Competence:

[Competence in analyzing and interpreting large datasets, identifying patterns, and using visualization tools to support decision-making while ensuring data privacy and ethical use.]

Not important Slightly important Moderately important Important Very important I don't know

AI Competences:

[Competence in understanding AI applications, evaluating their societal and organizational impact, and applying AI responsibly with transparency, fairness, and accountability.]

Not important Slightly important Moderately important Important Very important I don't know

Cloud Manufacturing Competence:

[Competence in leveraging cloud computing for manufacturing and automation, optimizing workflows, enabling remote monitoring, and integrating AI for predictive maintenance and decision-making.]

Not important Slightly important Moderately important Important Very important I don't know

Digital Solutions Design Competence:

[Competence in developing and optimizing software solutions for automation and digital process control, ensuring system reliability and integration of emerging digital tools.]

Not important Slightly important Moderately important Important Very important I don't know

30) Are any specific competences missing from the competence lists? If so, which ones?

Competence missing:

Competence missing:

Competence missing:

Competence missing:

31) Do you have any additional comments or insights from your organisation?

Section 3: Information about technical Staff

32) Primary Field of Work of the Technicians (Multiple Selections Possible)

- Mechanical & Electrical Engineering
- Computer Science / IT
- Manufacturing & Automation
- Energy & Sustainability
- Business Development
- Technical Engineering
- Cloud and Infrastructure
- Product Development & Research
- Marketing and Communications
- Operations
- Finance / Controlling
- Legal / Compliance
- Human Resources
- Customer Success
- Other

33) What is the highest level of educational attainment of the majority of typical technicians in your organisation (Multiple selections possible)

- 2-year Vocational Training (e.g., Apprenticeship, ITS, BTS, NVQ, EQF Level 4-5)
- 3-year Vocational Training (e.g., Advanced Apprenticeship, DUT, Higher National Diplomas EQF Level 5)
- Master Craftsperson / Technical Specialist (e.g., Meister, Techniker, Maître Artisan, Advanced Technician Diploma)
- Higher Vocational Diploma / Short-cycle Higher Education (e.g., Higher National Diploma, BTS, DUT, CFGS, EQF Level 5-6)

- Bachelor’s Degree (EQF Level 6)
- Master’s Degree (EQF Level 7)
- PhD / Doctorate (e.g., PhD, Dr.-Ing., Doktorat, EQF Level 8)
- Industry Certifications / Continuing Education Programs (e.g., Cisco, AWS, PMP, Lean Six Sigma, EQF Level varies)
- Other

34) If you want to be notified about the results of this survey, please insert your e-mail address

9.4 Transcription Excerpts (Anonymized)

The following excerpts were selected from twelve expert interviews conducted across five European countries and a variety of sectors including automotive, ICT, biomedical engineering, and technical education. The quotes were anonymized and grouped by thematic clusters to illustrate key qualitative findings.

Green & Sustainability Skills

"What we currently lack is the capacity to integrate sustainability and digital thinking together – our programs are still too separated in these dimensions." *(Italy – HVET Sector)*

"Technicians need to understand not only green technology, but when and how to implement it practically – for example, retrofitting rather than replacing entire systems." *(UK – SME Owner)*

Digital & Data Skills

"AI is entering our sector quickly, but the competence frameworks are lagging behind what’s needed in real projects." *(Spain – Automotive Industry)*

"Data literacy is the core gap – not just coding, but understanding how to structure, clean, and use data in real decision-making." *(Germany – IT Firm)*

Soft Skills & Autonomy

"Soft skills like autonomy and problem-solving are just as important as technical ones, but they are rarely taught explicitly." *(Germany – Engineering SME)*

"We need people who take initiative – not just wait for orders, but see the system and suggest improvements." *(France – Industrial Consortium)*

Education-Practice Gap

"There is a mismatch between training curricula and the actual pace of industry innovation. Students need more exposure to real workflows." *(Italy – Biomedical Sector)*

"Technicians don't lack intelligence – they lack real training in how to think across domains. Interdisciplinarity is still missing in our system." *(France – Educational Stakeholder)*

Industry-Academia Collaboration

"Universities must stop thinking of themselves as separate. HVET, companies, and universities should co-design training based on real workplace demands." *(Italy – Automotive Manufacturer)*

"Applied research skills are completely missing in our junior staff. We need concrete training in testing, documenting, and iteration." *(France – Mechatronics Lab)*

All names and affiliations have been removed to ensure confidentiality. Full transcripts are securely stored within the project consortium and available to auditors or reviewers upon request.

9.5 Relevance Matrices

All relevance matrices and statistical results have been fully presented and interpreted in Section 5.1 of this report.

The underlying SPSS data and correlation tables are stored within the project data environment and can be made available upon request to authorized reviewers under GDPR-compliant conditions.

9.6 Ethics and Consent

Participation in both the survey and interviews was voluntary. All participants received an information sheet and agreed to data processing under GDPR-compliant procedures.

- No personal identifiers were collected
- All interviews were anonymized and stored securely
- Ethical oversight was ensured by the project leadership team at DHBW Karlsruhe

A model consent form is available upon request.

9.7 Knowledge – Skills – Attitudes (KSA) (new labels)

To further specify and operationalize the identified competences, the following section provides a structured breakdown into Knowledge, Skills, and Attitudes (KSA). This enables a more precise understanding of what learners need to know, be able to do, and value in order to develop each competence effectively.

Table 14: Classification of HUCO Future Skills by Knowledge, Skills and Attitudes (KSA)

ID	Competence Name	Knowledge	Skills	Attitudes
FS-01	**Creative Problem-Solving Competence**	'Understand creative processes and techniques', 'Know methods for idea generation'	'Be able to ideate and prototype solutions', 'Be able to analyze feasibility of innovations'	'Demonstrate persistence in experimentation', 'Be open to unconventional approaches'
FS-02	**Applied Innovation Research**	'Know how to design applied research', 'Understand methodology selection'	'Be able to draft hypotheses', 'Be able to align research with innovation pipelines'	'Value rigor in experimentation', 'Display openness to interdisciplinary research'
FS-03	**Responsible Research Practice**	'Understand ethical principles in research', 'Know data protection and impact assessment'	'Be able to identify ethical dilemmas', 'Be able to apply ethical guidelines in practice'	'Demonstrate integrity in research', 'Respect societal implications of innovation'
FS-04	**Communication Competence**	'Know formats for scientific and technical communication', 'Understand audience-specific communication strategies'	'Be able to present findings across media', 'Be able to tailor language to diverse audiences'	'Be clear and transparent in communication', 'Display confidence in public engagement'
FS-05	**Interdisciplinary Collaboration Competence**	'Understand basics of multiple disciplines', 'Know collaboration strategies'	'Be able to integrate diverse perspectives', 'Be able to resolve conflicts in teams'	'Respect disciplinary diversity', 'Show commitment to shared goals'
FS-06	**Digital Modelling & Simulation Competence**	'Understand modelling principles and simulation tools', 'Know applications of virtual environments'	'Be able to test and refine digital prototypes', 'Be able to analyze simulation outcomes'	'Be precise in modelling', 'Display openness to iterative improvement'

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	Knowledge	Skills	Attitudes
FS-07	**Benchmark & Standards Competence**	'Know relevant industry standards', 'Understand regulatory frameworks'	'Be able to compare performance metrics', 'Be able to align processes with best practices'	'Demonstrate commitment to quality', 'Value continuous improvement'
FS-08	**Innovation Management Competence**	‘Know innovation processes and lifecycle’, ‘Understand methods for idea generation and evaluation’, ‘Know tools for managing innovation projects’	‘Be able to manage innovation workflows’, ‘Be able to apply creative problem-solving techniques’, ‘Be able to evaluate and scale innovative solutions’	‘Be open to change and experimentation’, ‘Show curiosity and forward-thinking’, ‘Value impact and feasibility of new ideas’
FS-09	**Project Leadership Competence**	'Understand project planning and lifecycle', 'Know methods for team coordination'	'Be able to manage milestones and risks', 'Be able to lead diverse teams'	'Show accountability in project work', 'Be solution-focused and resilient'
FS-10	**Research-Driven Competence**	'Understand R&D process and goals', 'Know how to evaluate development outcomes'	'Be able to plan research-based projects', 'Be able to implement development frameworks'	'Be rigorous and analytical', 'Value evidence-based progress'
FS-11	**Quality & Process Management Competence**	'Know quality control systems', 'Understand continuous improvement cycles'	'Be able to monitor performance indicators', 'Be able to optimize workflows'	'Strive for excellence', 'Be attentive to detail and process stability'
FS-12	**Entrepreneurial Thinking Competence**	'Know basics of business models and markets', 'Understand innovation strategies'	'Be able to identify opportunities', 'Be able to build entrepreneurial initiatives'	'Be proactive and risk-aware', 'Show perseverance and vision'
FS-13	**Self & Time Management Competence**	‘Understand principles of self-regulation’, ‘Know methods of time and task planning’, ‘Know stress management techniques’	‘Be able to structure and plan own learning processes’, ‘Be able to prioritize tasks and maintain focus’, ‘Be able to reflect and adapt behavior’	‘Show initiative and responsibility’, ‘Be self-directed and persistent’, ‘Value continuous self-improvement’
FS-14	**Sustainability Thinking Competence**	'Understand concepts of sustainability and circular	'Be able to evaluate ecological impact', 'Be able to promote sustainable practices'	'Show responsibility for future generations', 'Be committed to ecological values'

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	Knowledge	Skills	Attitudes
		economy', 'Know principles of resource efficiency'		
FS-15	**Systems Thinking Competence**	'Know systems theory basics', 'Understand system interdependencies'	'Be able to model complex systems', 'Be able to apply lifecycle thinking'	'Display holistic perspective', 'Embrace long-term impacts in decision-making'
FS-16	**Sustainable System Design Competence**	'Understand principles of eco-design', 'Know tools for sustainable planning'	'Be able to integrate green technologies', 'Be able to design for minimal resource use'	'Be committed to green innovation', 'Show creativity in sustainable engineering'
FS-17	**Digital Fundamentals Competence**	'Understand core digital tools and environments', 'Know how to navigate digital communication channels'	'Be able to manage digital files and platforms', 'Be able to use productivity software effectively'	'Display openness to digital change', 'Show responsibility in digital interactions'
FS-18	**Data Literacy Competence**	'Understand principles of data collection and analysis', 'Know how to interpret statistical information'	'Be able to visualize data clearly', 'Be able to transform data into insights'	'Value transparency in data use', 'Demonstrate curiosity for data-driven inquiry'
FS-19	**Cybersecurity & Privacy Competence**	'Know basic cybersecurity threats and countermeasures', 'Understand privacy regulations and protocols'	'Be able to assess digital risks', 'Be able to implement safe usage practices'	'Demonstrate responsibility in data handling', 'Be vigilant about digital threats'
FS-20	**AI-Literacy & Application Competence**	'Understand AI principles and algorithms', 'Know ethical concerns related to AI'	'Be able to use AI tools in workflows', 'Be able to interpret AI-generated results'	'Display critical awareness of AI impact', 'Act responsibly when applying AI'
FS-21	**Cloud-Based Manufacturing Competence**	'Understand distributed cloud systems', 'Know the principles of real-time collaboration'	'Be able to configure cloud-based tools', 'Be able to integrate cloud platforms in workflows'	'Show openness to decentralized collaboration', 'Respect the dynamics of remote production'

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	Knowledge	Skills	Attitudes
FS-22	**Digital Application Design Competence**	'Understand design principles for digital tools', 'Know usability and performance considerations'	'Be able to prototype digital applications', 'Be able to evaluate user feedback'	'Be user-oriented', 'Demonstrate adaptability in iterative design'

9.8 Learning Objectives (new labels)

The following table outlines learning objectives for each of the identified HUCO Future Skills. The objectives are structured according to Bloom's revised taxonomy, distinguishing between three cognitive levels:

1. basic understanding and recall (Levels 1–2),
2. practical application and analytical thinking (Levels 3–4), and
3. evaluative and creative performance (Levels 5–6).

These objectives serve as **didactic suggestions** to guide curriculum development, training design, and assessment strategies. They provide a structured starting point for translating each competence into concrete, observable learning outcomes across different levels of complexity and learner development.

Table 15: Learning Objectives for TRIComp Framework (Levels 1–6 by Bloom's Taxonomy)

ID	Competence Name	General Learning Objective	Learning Level 1–2 (Remember/Understand)	Learning Level 3–4 (Apply/Analyze)	Learning Level 5–6 (Evaluate/Create)
FS-01	**Creative Problem-Solving Competence**	Learners apply creative strategies to solve complex problems in innovation contexts.	Learners define creativity processes and distinguish problem types.	Learners apply ideation techniques to generate and refine solutions.	Learners evaluate and design breakthrough innovations in R&D contexts.
FS-02	**Applied Innovation Research**	Learners gain competence in designing and executing	Learners understand research logic,	Learners construct valid and reliable	Learners lead complex R&D processes and assess research impact.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	General Learning Objective	Learning Level 1–2 (Remember/Understand)	Learning Level 3–4 (Apply/Analyze)	Learning Level 5–6 (Evaluate/Create)
		applied innovation research projects.	methodology, and design elements.	research designs for innovation.	
FS-03	**Responsible Research Practice**	Learners are able to identify, address, and lead ethical practices in research and development.	Learners describe ethical frameworks relevant to research and technology.	Learners apply ethical standards in real-world scenarios.	Learners evaluate and create guidelines for responsible innovation leadership.
FS-04	**Communication Competence**	Learners become proficient in communicating scientific and technical content effectively.	Learners explain key elements of professional and scientific communication.	Learners apply strategic formats to tailor messages for diverse audiences.	Learner's design and evaluate communication strategies across media.
FS-05	**Interdisciplinary Collaboration Competence**	Learners are able to collaborate across disciplines to solve complex, interconnected challenges.	Learners describe principles of interdisciplinary teamwork.	Learners engage in team-based problem-solving with other disciplines.	Learners initiate and lead cross-sectoral innovation collaborations.
FS-06	**Digital Modelling & Simulation Competence**	Learners use digital simulation tools to model and test designs in research and development.	Learners explain the principles of digital modeling and simulation.	Learners use simulation tools to test prototypes and predict outcomes.	Learners develop complex simulations for decision-making in dynamic environments.
FS-07	**Benchmark & Standards Competence**	Learners apply benchmarking and quality standards to enhance process and product performance.	Learners define standards, benchmarks, and performance indicators.	Learners compare own practices to external benchmarks.	Learners integrate benchmarks into organizational learning and innovation cycles.
FS-08	**Innovation Management Competence**	Learners are able to understand, manage, and evaluate innovation	Recall stages of innovation processes;	Apply innovation frameworks to case studies; analyze	Evaluate innovation strategies and design

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	General Learning Objective	Learning Level 1–2 (Remember/Understand)	Learning Level 3–4 (Apply/Analyze)	Learning Level 5–6 (Evaluate/Create)
		processes and apply methods to generate and implement new ideas.	describe basic innovation models and tools	barriers to innovation in teams or organizations	original solutions for process or product improvement
FS-09	**Project Leadership Competence**	Learners develop leadership skills for managing and delivering successful projects.	Learners describe the project life cycle and team roles.	Learners manage scope, risk, and time in technical projects.	Learners lead complex initiatives and evaluate project performance and outcomes.
FS-10	**Research-Driven Competence**	Learners integrate scientific thinking into development processes and innovation cycles.	Learners recall scientific development steps and criteria.	Learners plan and implement research-driven development processes.	Learners lead iterative R&D strategies with continuous feedback loops.
FS-11	**Quality & Process Management Competence**	Learners apply quality assurance principles to optimize operations and ensure excellence.	Learners recognize quality principles, norms, and tools.	Learners apply quality checks and control mechanisms.	Learners build and assess organizational quality cultures and systems.
FS-12	**Entrepreneurial Thinking Competence**	Learners acquire an entrepreneurial mindset to identify opportunities and drive innovation.	Learners define innovation and entrepreneurship in technical contexts.	Learners create value propositions and test business models.	Learners lead entrepreneurial ventures and manage innovation ecosystems.
FS-13	**Self & Time Management Competence**	Learners organize their learning and work autonomously, reflectively, and responsibly in dynamic tasks and environments.	Learners identify key principles of self-management and recall tools for time prioritization.	Learners apply time management strategies in learning and work scenarios, and analyze personal	Learners evaluate personal routines and create a self-directed system for autonomous work and learning organization.

ID	Competence Name	General Learning Objective	Learning Level 1–2 (Remember/Understand)	Learning Level 3–4 (Apply/Analyze)	Learning Level 5–6 (Evaluate/Create)
				distractions and behavioral routines.	
FS-14	**Sustainability Thinking Competence**	Learners develop awareness and application of ecological and sustainable thinking in innovation.	Learners explain sustainability concepts like circular economy and lifecycle analysis.	Learners apply strategies for ecological innovation in design.	Learners design systems that promote long-term sustainability.
FS-15	**Systems Thinking Competence**	Learners understand and analyze systems dynamics to guide responsible decision-making.	Learners identify systemic relations and interdependencies.	Learners analyze complex systems and model interactions.	Learners synthesize systems insights to redesign structures for sustainability.
FS-16	**Sustainable System Design Competence**	Learners understand and analyze systems dynamics to guide responsible decision-making.	Learners identify systemic relations and interdependencies.	Learners analyze complex systems and model interactions.	Learners synthesize systems insights to redesign structures for sustainability.
FS-17	**Digital Fundamentals Competence**	Learners gain foundational digital fluency for working in modern digital environments.	Learners identify and describe core digital concepts and tools.	Learners apply safe and effective digital practices in varied technical contexts.	Learners design and evaluate new digital interaction strategies for learning and collaboration.
FS-18	**Data Literacy Competence**	Learners develop the ability to understand, analyze, and use data in professional contexts.	Learners understand and explain basic data types, structures, and uses.	Learners apply statistical tools to analyze datasets and generate insights.	Learners evaluate data quality and design models to solve complex data problems.
FS-19	**Cybersecurity & Privacy Competence**	Learners build awareness and practical competence	Learners recall types of cyber threats and	Learners analyze systems for vulnerabilities and	Learners design, evaluate and lead risk-aware

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Competence Name	General Learning Objective	Learning Level 1–2 (Remember/Understand)	Learning Level 3–4 (Apply/Analyze)	Learning Level 5–6 (Evaluate/Create)
		in digital safety and information protection.	describe security principles.	implement protective measures.	cybersecurity strategies across contexts.
FS-20	**AI-Literacy & Application Competence**	Learners understand how AI works and how to use it responsibly in applied settings.	Learners explain how AI systems function and describe ethical concerns.	Learners apply basic AI tools in technical or research environments.	Learners evaluate and develop responsible AI solutions considering societal impacts.
FS-21	**Cloud-Based Manufacturing Competence**	Learners develop skills to engage in cloud-based production systems and distributed collaboration.	Learners describe the concept of cloud-based production and related tech.	Learners operate and configure cloud manufacturing systems in projects.	Learners design and optimize distributed production environments.
FS-22	**Digital Application Design Competence**	Learners learn to create and implement digital solutions tailored to user and technical needs.	Learners recognize the steps of digital solution development.	Learners prototype and test functional digital applications.	Learners lead iterative innovation cycles and evaluate usability/performance.

9.9 Competence Labels (Old–New Mapping)

Introduction to the mapping table of renamed competence labels

The renaming of competence labels is grounded in two evidence sources: (1) the open free-text fields from the **quantitative interviews** (n = 150 participants) and (2) **twelve qualitative interviews** with a total of 12 interview partners. The conversations of four interview partners were consolidated into a single document; because these are four distinct voices, they are referenced as **Interview 7a–7d** and are counted as **four individual interviews** within the total of twelve. All other conversations are recorded as **Interview 1–6** and **11–12**.

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

The refinements prompted by interviews and free-text responses (e.g., risk/resilience, dissemination, language and cultural competence, decision-making under uncertainty, and self- and time-management) are already operationalised within the **KSA** and the **Learning Objectives**, as well as in the corresponding **competence descriptions**; the adjustments documented here are purely editorial (**labels only**).

Table 16: Terminology Update: Competence Labels (Old–New Mapping)

ID	Old Competence Name	New Competence Name	
FS-01	Creativity & Problem-Solving Competence	**Creative Problem-Solving Competence**	**Rationale:** Normalises wording; centres outcome-oriented **problem-solving** highlighted across interviews. **Evidence: Interview 4** (independent problem-solving, critical thinking); **Interviews 7a–7d** (problem-solving & lean).
FS-02	Design Research Competence	**Applied Innovation Research Competence**	**Rationale:** Avoids confusion with "research design" (methods) and foregrounds **hands-on, application-oriented** innovation (prototyping, testing, iteration). **Evidence: Interviews 7a–7d** (applied research skills; practical, SME-linked projects).
FS-03	Ethical Research Competence	**Responsible Research Practice Competence**	**Rationale:** Shifts from ethics-only to **responsibility** incl. research integrity and **data protection/privacy** in applied settings. **Evidence: Interview 1** (privacy awareness with AI tools); **Interview 4** (proper use of AI tools).
FS-04	Communication Competence	**Communication Competence**	
FS-05	Interdisciplinary Collaboration Competence	**Interdisciplinary Collaboration Competence**	
FS-06	Digital Simulation Competence	**Digital Modelling & Simulation Competence**	**Rationale:** Makes the full **M&S** workflow explicit (modelling precedes simulation) and matches industry phrasing. **Evidence: Interview 11** (design & modelling, statistics for modelling); **Interview 12** (simulation tools).
FS-07	Benchmark Orientation Competence	**Benchmark & Standards Competence**	**Rationale:** Broadens "benchmark" to explicitly include **standards/compliance** (sector/ISO norms) signalled by stakeholders;

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Old Competence Name	New Competence Name	
			labels only, constructs unchanged. **Evidence: Quantitative Interviews** (requirements compliance; production standards; quality control); **Interview 5** (state-of-the-art/technology watch).
FS-08	Innovation Management Competence	**Innovation Management Competence**	
FS-09	Project Management Competence	**Project Leadership Competence**	**Rationale:** Reflects expectations **beyond administration**: ownership, stakeholder alignment, decision-making. **Evidence: Interview 4** (ownership, autonomy); **Interview 11** (self-activation; method discipline).
FS-10	Research-Design Competence	**Research-Driven Competence**	**Rationale:** Removes ambiguity with "study design"; signals decisions guided by **research evidence & continuous inquiry**. **Evidence: Interviews 7a–7d** (applied research skills, documenting experiments); **Interview 4** (learning from documentation, testing).
FS-11	Quality Management Competence	**Quality & Process Management Competence**	**Rationale:** Adds explicit **process orientation** (SOPs, continuous improvement) requested by companies alongside quality. **Evidence: Interview 11** (Lean Six Sigma; process approach).
FS-12	Entrepreneurial Competence	**Entrepreneurial Thinking Competence**	**Rationale:** Clarifies the **mindset** (opportunity, value creation, responsibility) rather than firm ownership; initiative/self-activation stressed. **Evidence: Interview 11** ("ability to self-activate"); **Interview 4** (initiative, business impact).
FS-13		**Self & Time Management Competence**	Added to address repeatedly reported gaps in **independent structuring, prioritisation and follow-through** (self-activation, method discipline, documentation/reporting); **labels only -** constructs/items/scoring unchanged. **Evidence: Interview 4**; **Interviews 7a–7d**; **Interview 11**; **Interview 1**;

ID	Old Competence Name	New Competence Name	
			Quantitative Interviews (initiative; active/continuous learning; attention to detail; self-efficacy; crisis management; ambiguity).
FS-14	Sustainability Competence	**Sustainability Thinking Competence**	**Rationale:** Specifies the **decision/analysis** dimension (trade-offs, ROI, sequencing) rather than a generic umbrella. **Evidence: Interview 2** (efficientising existing machinery; ROI/cost–benefit framing).
FS-15	Systems Thinking Competence	**Systems Thinking Competence**	
FS-16	Systems Design Competence	**Sustainable System Design Competence**	**Rationale:** Makes **sustainability constraints & life-cycle** criteria explicit within system-level design decisions. **Evidence: Interview 11** (LCA/second-life logic); **Interview 12** (evaluate environmental impacts of projects).
FS-17	Digital Literacy Competence	**Digital Fundamentals Competence**	**Rationale:** Positions this as **baseline** digital systems knowledge, avoiding overlap with Data/AI literacy. **Evidence: Interview 4** (understanding of data and **IT systems** is missing).
FS-18	Data Competence	**Data Literacy Competence**	**Rationale:** Clarifies the full data pipeline (collect, **clean**, **harmonise**, **interpret**) explicitly named as a gap. **Evidence: Interview 4** (data literacy missing; how to handle/use data).
FS-19	Cybersecurity Competence	**Cybersecurity & Privacy Competence**	**Rationale:** Adds **privacy-by-design/data protection** explicitly alongside security risks in industrial/digital contexts. **Evidence: Interview 1** (industrial cyberattack; privacy caution with AI).
FS-20	AI Competence	**AI-Literacy & Application Competence**	**Rationale:** Separates foundational understanding from practical use; interviewees call for **proper use of AI tools** (not like search). **Evidence: Interview 4** (use AI tools properly); **Interview 12** (AI in skill set).

Co-funded by the European Union

ERASMUS-EDU-2024-PI-ALL-INNO – **HUCO LABS** – Project number: **101186024** – Project duration: **Nov. 2024 - Oct. 2027**

ID	Old Competence Name	New Competence Name	
FS-21	Cloud Manufacturing Competence	**Cloud-Based Manufacturing Competence**	**Rationale:** Terminology normalisation; scope unchanged but consistent with **IT system integration/cloud practice**. **Evidence: Interview 4** (integrate IT systems; work with Azure/IT architects).
FS-22	Digital Solutions Design Competence	**Digital Application Design Competence**	**Rationale:** Narrows to concrete **applications/products** with clear user/system boundaries; HMI/UX and integration emphasised. **Evidence: Interviews 7a-7d** (HMI usage & design knowledge); **Interview 4** (system integration); **Quantitative Interviews** (user-friendly; presentation skills).