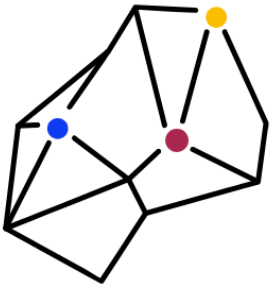


DIGI-ME

D1.1: Report on Targeted Skills Framework

Project No. 101123009

Co-funded by the European Union

Revision control

Version	Author	Partner	Date	Status
1	Sniazhana Diduc	UNIVAASA	02/07/2025	Initial draft
2	Sylviane Chabli	GEM	03/07/2025	Review
3	Isabelle Sauret	GEM	11/07/2025	Review
4	Sniazhana Diduc	UNIVAASA	15/07/2025	Second draft
5	Sniazhana Diduc	UNIVAASA	03/10/2025	Third draft
6	Arianna Tibuzzi	Obloo	11/10/2025	Review
7	Sniazhana Diduc	UNIVAASA	23/10/2025	Forth draft
8	Arianna Tibuzzi	Obloo	24/10/2025	Review
9	Adam Smale	UNIVAASA	24/10/2025	Proof reading

Disclaimer

The commercial use of any information contained in this document may require a license from the owner of that information. DIGI-ME members are also committed to publishing accurate and up to date information and take the greatest care to do so. However, the DIGI-ME members cannot accept liability for any inaccuracies or omissions, nor do they accept liability for any direct, indirect, special, consequential or other losses or damages of any kind arising out of the use of this information. In addition, this publication reflects only the DIGI-ME members' view and the European Commission is not responsible for any use that may be made of the information it contains.

Some portions of this work, particularly the systematic literature and data analysis, were supported by the use of large language models (LLMs) such as ChatGPT 4.0 Plus. All AI-generated outputs were reviewed by humans, verified against original sources, and assured for quality, accuracy, and reliability. Detailed use of AI and human oversight processes are provided on pg. 23 and in Appendix 2 of the report.

Table of Contents

Brief Description of the DIGI-ME Project

The "DIGItal skills for transformative Innovation Management and Entrepreneurship" (DIGI-ME) project received a grant from the European Commission to develop a community of EU leaders proficient in digitally enabled tools and processes for transformative innovation. It addresses Europe's priorities in sectors such as energy, healthcare, industry, transportation, and society. DIGI-ME offers high-quality personalized training within an EU ecosystem of complementary locations, providing advanced experiential learning in a world-class digital environment.

The project will deliver master's programs (120 ECTS) awarded by three EU HEIs (UNIPV, EESC GEM, and UNIVAASA), targeting students in economics, business administration, finance, management, engineering, and data science. The curriculum includes relevant digital technologies such as explainable AI, generative AI, augmented intelligence, digital twins, blockchain, data analytics, AI agents, and IoT.

More technical specifications can be found in the following table:

Project's name	DIGItal skills for transformative Innovation Management and Entrepreneurship (DIGI-ME)
Project's number	101123009
Implementation dates	Starting date: 01/02/2024 Completion date: 31/01/2028
Consortium partners	University of Pavia (UNIPV) University of Vaasa (UNIVAASA) Grenoble Ecole de Management (EESC GEM) Parco Scientifico Tecnologico Kilometro Rosso SpA (KMR) iGenius Obloo Lean Experience Factory (LEF) Consiglio Nazionale delle Ricerche (CNR)

Executive Summary

This report presents the updated Targeted Skills Framework (TSF v1.1) developed as part of the DIGI-ME project, which aims to enhance business master's programs with relevant digital competencies and skills. It responds to the increasing need for business education to evolve in light of digital transformation and shifting labour market expectations.

The report identifies the core challenges business programs face in adapting to these changes and outlines the rationale for integrating digital elements into their curricula. A revised methodology for developing the TSF v1.1 is presented, combining empirical data from multi-stakeholder workshops, a systematic literature review, and needs analysis. This methodological refinement supports the development of TSF v1.1. The framework includes four interlinked components: managerial competencies, digital competencies, proficiency levels, and emerging technologies. Each is grounded in evidence and supported by extensive data included in the annexes.

TSF v1.1 serves as a robust foundation for building digital capability within business education and provides practical guidance for educators, program designers, and institutional leaders.

1. Introduction

1.1 Purpose of the document

The purpose of this document is to present the findings that have emerged from the implementation of the refined methodology introduced in Deliverable D1.1 (January 2025) developed under Work Package (WP1) of the DIGI-ME project, along with the resulting iteration of the Targeted Skills Framework v1.1. That earlier document outlined a structured, forward-looking approach for developing a Targeted Skills Framework (TSF) to guide the integration of evolving digital competencies into higher education programs.

This deliverable now illustrates how the methodology was applied across each of the partnering Higher Education Institution (HEIs) within the DIGI-ME consortium. It captures the insights gained to further advance TSF, variations in local implementation, and the collaborative validation processes undertaken with regional stakeholders to ensure contextual relevance. The document demonstrates how the resulting TSF is being embedded into the enhancement of master's degree programs offered by the partner HEIs. It highlights how these programs are evolving to address the rapidly changing digital competence and skill demands of the labour market and respond to institutional, regional, and sectoral needs as well as the training needs of lifelong learners by co-developing certifications.

The DIGI-ME project is grounded in the recognition that digital transformation is reshaping the business landscape, thereby challenging HEIs to adapt their curricula to equip graduates with relevant digital competencies. Business studies programs, in particular, must evolve to integrate digital knowledge, competencies and skills that align with emerging workplace demands. This need is urgent, as graduates must be prepared not only with traditional business acumen but also with a functional and strategic understanding of digital technologies, tools and the ways they shape traditional businesses. In parallel, the regulatory landscape in Europe is rapidly evolving. The adoption of the EU Artificial Intelligence (AI) Act in 2024 is a major step toward ensuring trustworthy, transparent, and human-centric AI. This regulation has important implications for higher education and business programs, as it reinforces the need to equip business graduates with not only technical, but also ethical and governance-related digital competencies. It is important to note that the possibilities for developing and updating business programs are not uniform across all HEIs as they might be constrained by the national legal and regulatory frameworks governing higher education in each country such as Finland, Italy, and France, which influence the flexibility and speed with which curricula can be revised.

Despite the growing importance of digital transformation, many business studies programmes remain insufficiently equipped to respond. This shortfall stems from several interconnected issues. First, business faculty often lacks the specific digital knowledge or pedagogical tools required to effectively teach digital competencies. Many instructors need support both in terms of digital teaching tools and access to relevant educational software. The absence of structured institutional support and investment in upskilling faculty constraints the digital adaptation of curricula. Second, current curriculum design frequently treats student cohorts as homogeneous with unvarying intended learning outcomes (ILOs) and fixed content progression. This is particularly problematic in the context of digital skills, where students may enter programmes with highly variable levels of prior knowledge. The one-size-fits-all approach limits students' ability to develop competencies at the pace and level appropriate to their starting point. Personalization, therefore, emerges as a necessary design principle to ensure meaningful skill development and progression. Third, the conventional pace of curriculum development within HEIs is often too slow to keep up with the rapidly evolving nature of digital transformation. The dynamic nature of digital tools and technologies requires curricula that are continuously reviewed, adapted, and refined.

In the light of the underlying challenges that the DIGI-ME project seeks to address, the core objective of this deliverable is to present the latest iteration of TSF v1.1 and to outline the integration process of targeted digital competencies into the enhancement of master's degree programmes across participating institutions, laying the groundwork for future-oriented, digitally enriched curricula. While this iteration of TSF primarily focuses on higher education institutions and the DIGI-ME programme offering, the way TSF and its digital competencies have been developed also support the definition of certification pathways for lifelong learners, ensuring broader applicability beyond degree programmes.

Importantly, the TSF also brings an added value to existing frameworks such as DigComp by introducing an iterative approach to skills identification and validation. This feature ensures that new digital competencies can be recognized, validated, and embedded into learning pathways more rapidly, responding to the fast pace of technological change. Such an approach addresses one of the major challenges in business master's programmes, which often struggles to update curricula quickly enough to reflect emerging digital skills. By combining DigComp's robust structure with TSF's agility, the framework provides a more dynamic and responsible mechanism for embedding digital competencies into higher education.

At the same time, future versions of DigComp will remain a key point of reference for the DIGI-ME project. As DigComp continues to evolve through contributions from diverse European and international stakeholders, it ensures global alignment and societal relevance for digital skills. The DIGI-ME project acknowledges this value and positions the TSF as complementary to DigComp: while the TSF supports responsiveness to local and institutional contexts, DigComp provides a globally recognized framework that enables graduates to be equipped as international leaders. This dual approach ensures that the DIGI-ME project produces outcomes that are locally grounded, internationally relevant, and adaptable to the fast-changing digital landscape.

1.2 Content of the document

This report begins by outlining the key challenges currently faced by business education programs, particularly the growing need to enhance them with relevant digital competencies and skills. It examines the underlying drivers of this transformation, including evolving labour market demands, digital disruption across industries, and the shifting expectations of learners. Potential barriers to integration such as institutional inertia, varying levels of digital readiness, and misalignment between curricula and industry needs, are also briefly discussed to contextualize the need for change.

Following this, the report provides a concise overview of the project's structure and phases, situating this deliverable within the broader framework of the DIGI-ME project. It clarifies how this report is connected to earlier and forthcoming phases and work packages, demonstrating its contribution to the overall development and implementation of digitally enhanced business programs.

The report then outlines the revised methodology for developing the TSF, originally proposed in Deliverable D1.1 (Chapter 2). This section explains how the methodology has been refined and executed in this iteration, including empirical data collection through stakeholder workshops, systematic literature review, and needs analysis.

Chapter 3 presents the core outcome of this process: the Targeted Skills Framework version 1.1 (TSF v1.1). Each of its components, managerial competencies, digital competencies, proficiency levels, and technologies, is described in detail, drawing on empirical data included in the appendices. This chapter reflects a significant advancement from the earlier version, offering a more nuanced and practice-oriented structure for embedding digital skills in business curricula.

Chapter 4 illustrates how TSF v1.1 adds value to the master's programs selected for the DIGI-ME offering. It details how the integration of digital competencies and skills will enhance the educational experience and better align graduates' capabilities with labour market expectations.

The report concludes with a reflection on next steps, including areas for further development.

1.3 Use of the document

This deliverable is part of a broader sequence of project phases that structure the development and implementation of the DIGI-ME TSF. While the overall project encompasses multiple stages (see Figure 1), this document focuses primarily on Phase 2, which concerns the implementation of the revised methodology and the resulting iteration of the TSF v.1.1.

Figure 1. Project Phases Overview

The deliverable provides a detailed account of how the methodology was applied across the participating HEIs, what findings emerged from this application, and how those findings informed the design of the TSF v1.1. This iteration is not final, rather it represents an evolving framework subject to further refinement through future testing and validation cycles.

In addition, the document also touches on Phase 3, offering an illustrative overview of how the TSF v1.1 is planned to be embedded into the master's programmes within the partner HEIs. This includes examples of alignment between the framework and specific programme outcomes, as well as planned curriculum adjustments.

To ensure clarity and consistency in the use of this document, it is essential to establish a shared understanding of key terms central to the framework's development. Providing clear definitions ensures alignment among stakeholders and supports the document's effective application across different institutional and professional contexts.

Attitude is an individual's disposition or tendency to respond positively or negatively towards an idea, object, person, or situation, which influences behaviour (OECD, 2018).

Competency is defined as a combination of "complex know-how based on the effective mobilization and combination of a variety of internal and external resources within a family of situations" (Tardif, 2006). This conceptualization emphasizes the active and applied nature of knowledge within real-world professional settings.

Competency Framework is a framework that is based on the activities of business managers and the competencies they need to perform them successfully, while being a player in the digital transformation and integrating issues related to sustainable development into their professional practices (definition developed by DIGI-ME partners).

Digital Competency involves the "*confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It is defined as a combination of knowledge, skills, and attitudes*" (Council Recommendation on Key Competences for Lifelong Learning, 2018). This definition underlines the multifaceted nature of digital competency, extending beyond technical proficiency to include ethical and responsible engagement with digital tools (Ferrari, 2013).

Digital Skills refer to a range of abilities to use digital devices, communication applications, and networks to access, manage, and process information. These skills enable individuals to "*create and share digital content, communicate and collaborate, and solve problems for effective and creative self-fulfilment in life, learning, work, and social activities at large*" (Vosloo, 2018).

Dimension refers to the structure of the framework outlining the way in which the content of the framework is displayed. In Digi-Me, the concept of 'dimension' is used in the same way as it is used in the eCompetence framework for ICT professionals (e-CF) and DigComp framework (DigComp).

Family of jobs is a group of jobs involving similar types of work and requiring similar training, skills, knowledge, and competencies (U.S. Office of Personnel Management adopted by EU Skills Panorama).

Knowledge is the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study (European Qualifications Framework).

Targeted Framework is a structured model that identifies and organizes specific skills required for a particular group of learners, industry, job family, or educational objective. Unlike generic frameworks (e.g., DigComp or EQF), a targeted skills framework is tailored for a specific context such as a particular sector (e.g., digital marketing), audience (e.g., master's students), or purpose (e.g., employability or curriculum reform) (Cedefop, 2020).

The DIGI-ME project has adopted a **Targeted** Skills Framework approach in order to respond more effectively to the evolving digital skills needs of business education. This targeted orientation is critical to the DIGI-ME project for several reasons. First, generic frameworks provide useful taxonomies of skills, but often lack the specificity required to actionable integration into discipline-specific curricula. The DIGI-ME framework aims to map digital competencies directly onto these job roles and job families to ensure relevance. Second, master's students in business programmes come with varying digital skills levels and professional goals. A generic framework fails to capture this diversity. The targeted approach allows institutions to design differentiated learning pathways that reflect learners' starting points, professional trajectories, and program-specific aims. Lastly, it is important to articulate *why* DIGI-ME has developed a new framework rather than simply adopting existing EU models. While EU-level frameworks such as DigComp are valuable for benchmarking, they do not fully address the particular needs of the project's context. The DIGI-ME framework is a necessary adaptation that embeds specificity, stakeholder input, and contextual depth, elements that generic models cannot adequately provide.

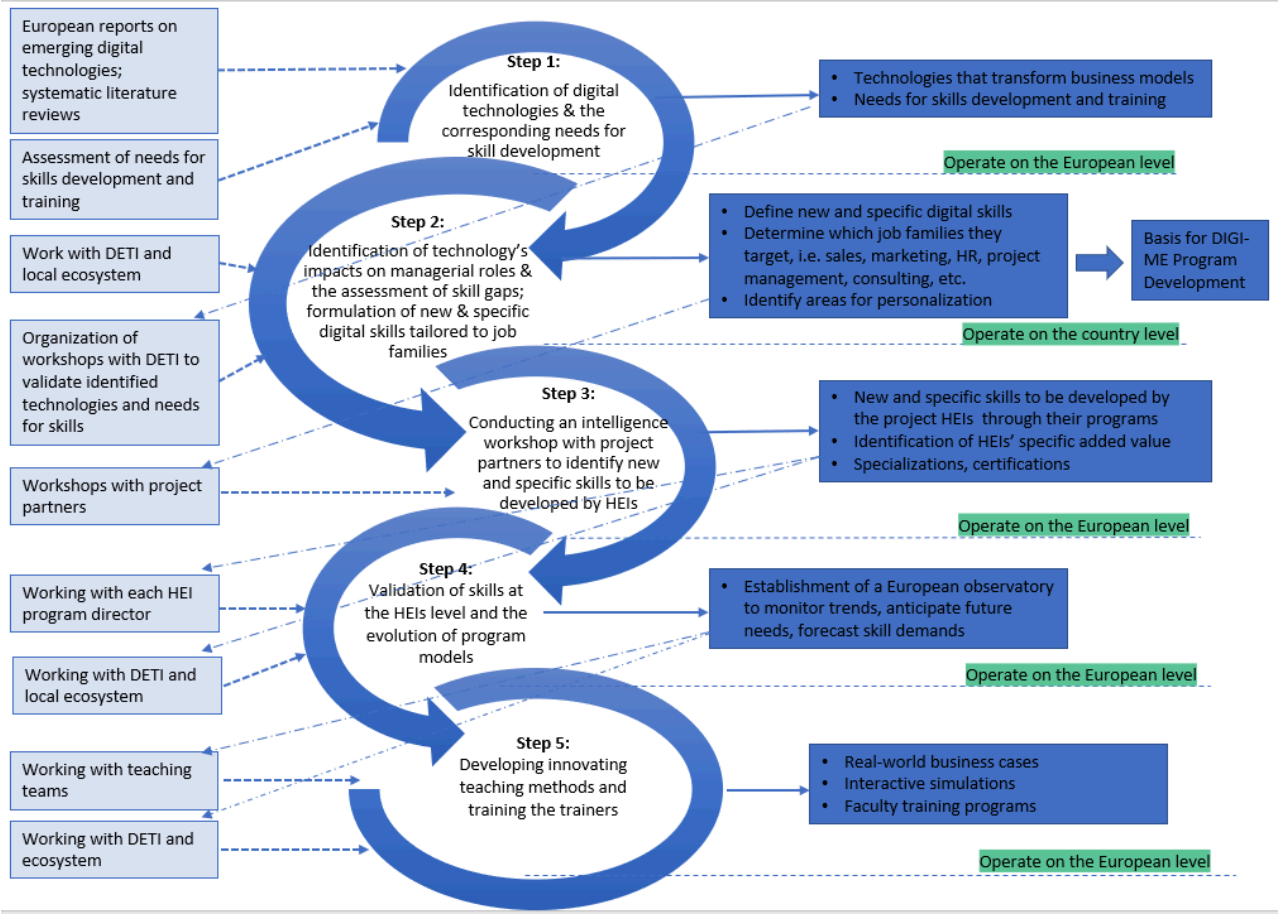
Use cases/family of situations are a specific real-world scenario or context in which a skill is applied to achieve a goal or solve a problem (OECD Learning Compass 2030).

2. From Methodology to Framework: Implementation Across HEIs

This section outlines how a forward-looking methodology for developing and continuously updating the DIGI-ME Targeted Skills Framework was implemented across the partner HEIs within the DIGI-ME consortium. It begins by briefly highlighting the key steps of the refined methodology introduced in Deliverable D1.1 (January 2025), then illustrates how these steps were implemented across the partner HEIs.

2.1. Key Steps of the Refined Methodology

The key steps of the refined methodology are presented in Figure 2 and briefly summarized below.



DETI – Digital Ecosystem for Transformative Innovation

Figure 2. Targeted Skills Framework Methodology Development

Step 1: Identification of Transformative Digital Technologies

Building on the Year 1 (phase 0 in Figure 1) needs analysis and competency mapping of the European labour market (results of the needs analysis and competency mapping are provided in D1.1 version submitted on 31.01.2025) and technology trends, the DIGI-ME methodology combines speculative and evidence-based approaches to identify digital technologies reshaping business models and workflows. It integrates forward-looking tools such as forecasting and the Ecosystem for Transformative Innovation (DETI) to anticipate emerging technologies like AI, blockchain, and IoT, while grounding these insights through a

dynamic literature review that contextualizes trends within historical, technological, and economic developments. This balanced and iterative process ensures a robust understanding of technological transformation and highlights the specific competencies needed for evolving business roles.

Step 2: Validation with Local Stakeholders

This step engages local stakeholders, particularly members of the DETI, WP2 in this DIGI-ME project, in workshops to validate the findings from Step 1. These interactive sessions ensure that identified technologies and their associated skill needs are relevant and actionable within specific regional and sectoral contexts. Through these discussions, new responsibilities, emerging tasks, and critical skill gaps are identified, forming the foundation for defining specific digital skills essential for modern business managers.

Step 3: Collective Intelligence Workshops

In this collaborative phase, project partners from participating HEIs work together to pool expertise and prioritize the digital skills to be integrated across institutions. These workshops are designed to foster a shared understanding of institutional strengths, define core competencies applicable across all HEIs, and localize additional competencies specific to regional job families and roles. By mapping these competencies to defined job families, the workshops ensure alignment between academic programmes and workforce requirements.

Step 4: Institutional Validation and Observatories

Each participating HEI conducts a thorough validation of the proposed framework at the programme level. This includes working closely with DETI partners to anticipate future needs and ensure the framework remains forward-looking. A key innovation in this step is the establishment of a European Competency Observatory. This observatory acts as a collaborative platform where HEIs and their ecosystems monitor trends, forecast skill demands, and share findings annually. The observatory ensures the framework is continuously updated to reflect the latest developments in technology and the labour market.

Step 5: Innovative Teaching Methods and Resource Development

Teaching teams are tasked with developing immersive and engaging pedagogical approaches tailored to diverse audiences. This includes creating real-world business cases, interactive simulations, and modular resources that align with the dynamic nature of digital

competencies. Faculty training programmes are also introduced, equipping educators with the tools and knowledge needed to effectively teach advanced digital technologies and methodologies. In practice, this entails collaboration between university lecturers, partners and local DETI to jointly develop curricula.

Regular feedback loops are integrated into the methodology to ensure its continuous improvement.

2.2. Applying the Refined Methodology Across HEIs

While the refined DIGI-ME methodology includes five iterative steps, this deliverable focuses on the implementation of Steps 1 through 4, which form the foundation for the development of the Targeted Skills Framework version 1.1 (TSF v1.1). These steps were carried out through a combination of joint and institution-specific activities across the partner HEIs.

Step 1: Identification of Key Digital Technologies and Skill Development Needs. This step was implemented collectively across the consortium, drawing on existing literature, findings from the earlier implemented EU-funded projects, and expert validation. The outcomes of the needs analysis, along with an extensive needs assessment, are detailed in Deliverable D1.1 (January 2025). The key emerging technologies were identified by our partner Grenoble School of Management (GEM), and validated by Professor Federico Pigni, Professor of Information Systems at GEM. The selection process relied on several authoritative sources, including Gartner's Emerging Technologies Report (2025), Hype Cycle for Emerging Technologies (2025), and Adoption Radar 2025: A visual representation of emerging technologies. To support deeper reflection, a deck of 24 technology cards was developed (Annex 1), detailing each emerging technology and its potential applications in managerial functions.

Step 2: Mapping Impacts on Managerial Roles and Identifying Local Skill Gaps. In this phase, each partner HEI conducted a context-specific analysis of how the identified technologies affect managerial and operational roles within their respective ecosystems. Using each HEI's own specific ecosystem (also known as DETI – Digital Ecosystem for Transformative Innovation – approach to its development was suggested by the consortium partner GEM and described in more details in WP2), partners assessed local skill gaps and translated them into targeted digital competencies aligned with regional labour market needs.

The following subsection provides a summary of the activities and results from each HEI during this step.

2.2.1 University of Vaasa

In line with Step 2 of the refined methodology, the University of Vaasa conducted an analysis on how emerging digital technologies impact managerial and operational roles within the Ostrobothnian business ecosystem in Finland. This phase aimed to translate observed changes into targeted digital competencies that respond to evolving labour market demands. The University of Vaasa adopted the DETI (Digital Ecosystem for Transformative Innovation) approach, applying its workshop design model to engage relevant local stakeholders. Specific steps of this approach applied by the University of Vaasa are presented below.

The identification of suitable companies for participation in the DETI process was guided by their alignment with the DIGI-ME project's thematic focus. Ten companies were selected as DETI partners based on their active involvement in digital transformation and their strategic importance to the local economy. These companies span a range of sectors including energy, electrification, manufacturing, IT infrastructure, and consulting. A full list of participating companies, along with descriptions and relevance to the project, is presented in the Table below.

Table 1. Analysis of the Companies from the ecosystem – University of Vaasa

Company	Overview	Suitability for DIGI-ME
Merinova	Leading actor in the **EnergyVaasa cluster**, providing growth and success for energy technology companies in the Vaasa region through project expertise and development services. merinova.fi	Highly suitable due to its central role in the energy technology sector and its extensive network within the EnergyVaasa cluster.

Wärtsilä	A global leader in **smart technologies** and complete lifecycle solutions for the marine and energy markets, with significant investments in innovation, such as the Smart Technology Hub in Vaasa. wartsila.com	Highly suitable due to its focus on smart technologies and innovation in the energy sector.
ABB	A pioneering **technology leader in electrification and automation**, with a strong presence in Vaasa's energy cluster. https://new.abb.com/fi	Highly suitable due to its focus on digital industries and automation technologies
Danfoss Drives	Specializes in AC drives essential for high-power battery systems and hybrid or all-electric solutions, contributing to **energy efficiency.** https://www.danfoss.com/en/products/dds/	Highly suitable, given its role in energy efficiency and digital solutions in power systems.
Atea	A leading **IT infrastructure** provider in the Nordic and Baltic regions, recognized as one of the world's most sustainable companies in 2024. atea.fi	Suitable, given its expertise in IT infrastructure and commitment to sustainability, aligning with digital competencies.
KPMG	A global network of professional services firms providing audit, tax, and **advisory services**. https://kpmg.com/fi/fi/home.html	Suitable, as its advisory services can offer insights into digital transformation and strategic business development
Muova	A design center focusing on **innovative product and service development**, collaborating with companies and research institutions. https://www.muova.fi/	Suitable, as its design expertise can provide valuable insights into user-centric digital solutions.

JHL ry	The **Trade Union** for the Public and Welfare Sectors in Finland, representing various professionals. https://www.jhl.fi/tietoa-jhlsta/yhteystiedot/	Moderately suitable; while not directly linked to digital competencies, it represents a broad member base that could benefit from digital skills.
Mirka	A **leading manufacturer** of abrasives and sanding solutions, headquartered in Finland. https://www.mirka.com/en/company/contact-us	Moderately suitable; its manufacturing background can provide insights into digital competencies in production processes.
UPC	UPC Print is part of UPC Centre which comprises UPC Print, UPC Media, UpCode, Wasa Innovation Center, Bock's Corner Brewery and Bock's Corner Village. UPC **offers on-line, in-line and off-line solutions for communication** printed on the web or through mobile. https://www.finlandcleantech.fi/company/upc-print/	Moderately suitable; its manufacturing background can provide insights into digital competencies in production processes. The owner's extensive background in investing activities provides insights related to the digital needs in the local ecosystem.

To validate and enrich the initial technology mapping and needs assessment, a series of workshops was conducted with representatives from the selected DETI companies. The workshops were designed as structured, participatory forums where practitioners could openly reflect on current and anticipated technological shifts, their implications for business roles, and the skills managers will need to respond effectively. In total, seven workshops were conducted, involving 14 participants. These sessions included both group workshops (4–5 participants) and individual interviews with each lasting approximately 60 minutes.

Participants expressed high levels of engagement and motivation, viewing the workshops as a rare and valuable opportunity to exchange views across organizational boundaries. Many

noted that the challenges raised by digital transformation are shared across sectors, suggesting a common landscape of emerging issues and required responses. The dialogic nature of the workshops allowed for mutual learning and the articulation of tacit concerns around workforce readiness, organizational change, and competitive positioning.

The key objectives of the workshops were to explore how digital technologies are reshaping managerial roles and responsibilities, to identify and define the emerging digital competencies required for future business leaders, and to generate actionable insights for aligning academic training with evolving industry needs. The workshops were built around three sequential tasks, each intended to prompt different layers of insights:

1. *Formulating complex managerial competencies*. Participants were asked to describe a complex managerial task or competence in their current professional setting by identifying core knowledge domains, capabilities and skills and supporting resources.
2. *Emerging digital technologies and their impact*. Using a deck of 24 technology cards (see Annex 1), participants were invited to select 2-3 technologies perceived to have the most significant impact on their organizations over the next five years. They then discussed the ways in which these technologies are expected to transform business operations or value creation as well as the emerging challenges these shifts pose for managerial roles.
3. *Anticipating future digital competency needs*. Building on previous steps, participants reflected on the digital competency needs. This task aimed to extract concrete, forward-looking digital competencies that could be integrated into the evolving DIGI-ME Targeted Skills Framework.

The findings from these workshops provided the University of Vaasa with a validated and locally grounded understanding of digital competency needs. These insights informed both the design of the TSF v1.1 and its alignment with regional industry expectations, reinforcing the project's core principle of contextual relevance in digital skills development.

A summary of the workshops and participants profiles is presented in the Table below.

Table 2. Summary of the workshops

Workshop number	Date	Duration	Participating companies	Number of participants
Online workshop #1	25.03.2205	60 min	Atea, Wärtsilä, JHL ry, KPMG	1. Lead solution Consultant

				2. HR Manager 3. Team Lead teach & data law 4. Area Manager
Online workshop #2	01.04.2025	60 min	ABB	1. Solution Development Manager
Online workshop #3	02.04.2025	40 min	Muova	1. Senior Researcher
Online workshop #4	04.04.2025	60 min	ABB, Danfoss Drives, Merinova	1. Director 2. Business Solution Architect 3. AI & Cybersecurity Leader 4. Project Manager 5. Sales & Marketing Manager
Online workshop #5	08.04.2025	60 min	Mirka	1. Chief Architect
Online workshop #6	14.04.2025	50 min	ABB	1. HR Manager
In person workshop #7	05.05.2025	90 min	UPC	1. Owner, investor

2.2.2 University of Pavia

Pilot DETI workshop. The main objective of the workshop was to identify digital and managerial competencies, foster connections within the Italian digital ecosystem, and align insights with the training programs to be developed under the DIGI-ME project. The workshop took place online on April 24th, 2025, via the Microsoft Teams platform, and lasted approximately two hours. Participant organizations were consortium partners,

specifically Kilometro Rosso, Domyn, and CNR. Since these organizations operate across various fields of science and technology, drawing on the consortium's expertise is helpful in achieving the project's main objectives. Additionally, two master's students and one PhD candidate from the University of Pavia took part, bringing the total number of participants to eight (see Table 3). Finally, a Miro Board was used to facilitate the workshop implementation and further collaboration between the participants.

Table 3. Analysis of the Companies – University of Pavia

Organizations	Overview
Kilometro Rosso SPA	Kilometro Rosso SPA is a science and technology park located in the Lombardy region of Italy. It is a large research and innovation center that hosts a wide range of companies, institutions, and organizations involved in various fields of science and technology.
Domyn	Domyn is a company specializing in researching and developing Responsible AI for regulated industries, including financial services, government, and heavy industry. It supports enterprises with proprietary, fully governable solutions, based on a composable AI architecture- including LLMs, AI agents, and one of the world's largest super computers.
The Italian National Research Council (CNR)	The Italian National Research Council (CNR) is the main public research organization of Italy, whose aim is to perform, promote, spread, transfer and improve research activities in the main sectors of knowledge. The CNR consists of about 100 different research institutes that span from human sciences to engineering sciences.
UNIPV	The University of Pavia (UNIPV) is one of the world's oldest academic institutions: it was founded in 1361 and until the 20th century it was the only university in the Milan Area and the region of Lombardy. Today it is a comprehensive university, which covers all subject areas - Science and Technology, Engineering, Life Sciences, Humanities and Social Sciences - and is composed of 18

	Departments offering study programs at all levels, from bachelor's degrees to Doctorate programs.

Following the proposed methodology by GEM for the DETI competencies workshop, the workshop conducted by UNIPV consisted of three main phases, as explained in table 4.

Table 4. Phases of the competencies workshop conducted by the University of Pavia

Phases	Specifications
Phase 1. Competence formulation	Participants were asked to define a complex managerial competence or an ability to act within their professional context. They were also asked to identify the contribution of knowledge, skills, and other resources to this competence.
Phase 2. Identification of emerging technologies	Participants selected two to three technology cards (Appendix 1. The Key Emerging Technologies), based on the needs they considered most relevant for the next five years, within their organizations.
Phase 3. Alignment between market requirements and current didactical offer, taking into consideration the International Business and Entrepreneurship (MIBE) program, and its main tracks: a) International Management, b) Digital Management, c) Sustainable Management.	Participants were asked to identify four key aspects after reviewing the current MIBE study plan: a) Alignment with job market and professional needs: Do the professional or academic profiles correspond to the labour market demand?; What are the typical roles within your organization and/or sector for the professional and/or academic profiles discussed? b) Skills: What skills are required?; Are the skills intended to be provided to graduates consistent with the needs of your professional sector?; Are they

	enough for the typical roles in your organization?; What skills should a graduate of this degree program possess to match the professional profiles the program aims to develop?; Are there any transversal skills that a graduate of this program should possess? c) Coherence, communication and structure of the program: Are the educational objectives consistent with the needs of your sector?; Do you believe that the set of courses included in the study plan is adequate for achieving the educational objectives and the specific competencies? d) Evaluation of the program: What do you consider to be the strengths of this degree program?; What do you consider to be the weakness of this degree program?

Systematic Literature Review

The main objective of the systematic literature review was to evaluate the use and implementation of future technologies and digital skills within the education sector. This effort aims to support the development of TSK v1.1. The research methodology was implemented through a bibliographic search strategy, identifying first various sets of keywords that were then divided into three conceptual categories: a) education; b) digital skills/technology; c) managerial skills/soft skills. Two databases were selected to conduct the research: Web of Science (WoS) and Scopus. The original database included 535 articles. After excluding those not available in English, those without full-text access, and those deemed irrelevant based on abstract review, the final database comprised 371 articles. The database included the collection of various types of information, such as bibliographic details (authors' names, publication titles, sources, types of publication, and years of publication), research objectives (main research questions and hypotheses), and key findings

(relevant results, types of digital and managerial skills and competencies identified, and suggested directions for future research). Data analysis was supported by ChatGPT 4.0 Plus, consistent with the guidelines provided by Leas et al. (2024), who noted that large language models can assist across various phases of data analysis. Similarly, Kuppelwieser et al. (2025) highlighted advantages of AI integration in literature reviews, such as more comprehensive responses, improved organization, and enhanced efficiency. However, researchers like Bijker et al. (2024) and Marvin et al. (2024) emphasized the importance of multiple iterations, clear and well-structured prompts, and verification against original sources to ensure reliability and minimize hallucinations. Following these recommendations, this study tested and refined prompts on a representative subsample of at least 20% (n=74), focusing on verifying citations and maintaining theoretical alignment (Kuppelwieser et al., 2025). The validated results previously confirmed through Excel and ATLAS.ti analyses were then applied to the complete database. Further details are available in Appendix 2 of this document.

2.2.3 Grenoble School of Management

In line with Step 2 of the refined methodology, GEM initiated contact with various organizations, including companies and professional associations, to engage in a collective discussion regarding the training of current and future business managers in emerging digital technologies.

These organizations could also be interested in joining the DETI, which is currently being developed.

Table 5. Companies participating in the competencies workshops - GEM

Company	Overview
Tessi	Tessi is a major European player in BPS (Business Process Services). For over 50 years, they have been reinventing themselves on a daily basis to help manage the digital transformation of all kinds of businesses. https://www.tessi.eu/en
Probabl.ia	Probabl's mission is to develop, maintain at the state of art, sustain, and disseminate a complete suite of open source tools for data science. https://probabl.ai/
Poma	POMA is a leader in ropeway transport, recognised worldwide for its efficient and eco-friendly mobility solutions.

	With its innovations and know-how, POMA takes up all the challenges of mobility all around the world. https://www.poma.net/en
OnePoint	Onepoint is a French company specializing in the digital transformation of businesses and organizations. https://www.groupeonepoint.com/fr
Club des Entreprises USMB	A non-profit organization and partner of the University of Savoie Mont Blanc, their mission is to connect businesses and academia. For over 25 years, the Club des Entreprises has been a unique player in the French academic landscape, bringing together 100 member companies and institutions and over 1,000 partners. https://www.club-entreprises.univ-smb.fr/
CEA	The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas: defence and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences. https://www.cea.fr/
Départements de Savoie et Haute Savoie, Direction de la lecture public Savoie et Haute Savoie	The Reading Department of the Savoie Public Services works to promote reading and cultural activities in the Savoie region in collaboration with departmental services, educational, cultural and social institutions and associations, book professionals, the Region and the State. https://hautesavoie.fr/en-pratique/culture-patrimoine/lecture-publique/

During these collaborative workshops, the DIGI ME project was presented to them, along with the value proposition:

"Accelerate, through co-development, the organizational capabilities in innovation and digitalization of innovative companies and start-ups, while reducing the risks linked to the integration of new digital technologies."

Two series of collaborative workshops were organized (see table below).

Table 6. Summary of the workshops organized by GEM

Workshop number	Date	Duration	Participating companies	Number of participants
Hybrid workshop #1 1st session	02/12/2025	120 min	Tessi, Probable.ia, Poma, OnePoint	1. Group Human Resources Director 2. Training Director 3. HR Manager 4. Consultant 5. Business Developer 6. Strategy and New Market Director
Hybrid workshop #1 2nd session	03/18/2025	120 min	Tessi, Probable.ia, Poma, OnePoint	1. Group Human Resources Director 2. Training Director 3. HR Manager 4. Consultant 5. Business Developer 6. Strategy and New Market Director
Hybrid workshop #1 3rd session	04 02 2025	120 min	Tessi, Probable.ia, Poma, OnePoint	1. Group Human Resources Director 2. Training Director 3. HR Manager

				4. Consultant 5. Business Developer 6. Strategy and New Market Director
In person workshop #1 1st session	06 17 2025	120 min	CEA, Départements de Savoie et Haute Savoie, Club des Entreprises USMB	1. HR Partner 2. Project Manager 3. Digital and Evaluation Officer
In person workshop #2 2nd session	06 25 2025	120 min	Départements de Savoie et Haute Savoie, Club des Entreprises USMB	1. Project Manager 2. Digital and Evaluation Officer

The aim of these workshops was to identify the digital skills that current and future business managers in our ecosystem need to develop, so that GEM can adapt its MSc training program to the real and evolving needs of the job market, and respond to the training needs of Life Long Learners by co-developing certifications.

Another goal was to create or strengthen the connections between GEM and organizations in the Grenoble entrepreneurial ecosystem, with the intention of involving them in the DETI.

GEM's approach for these collaborative workshops:

The two series of collaborative workshops had different formats (three 2-hour sessions for the first, and two 2-hour sessions for the second), but followed similar steps, as summarized in the diagram below:

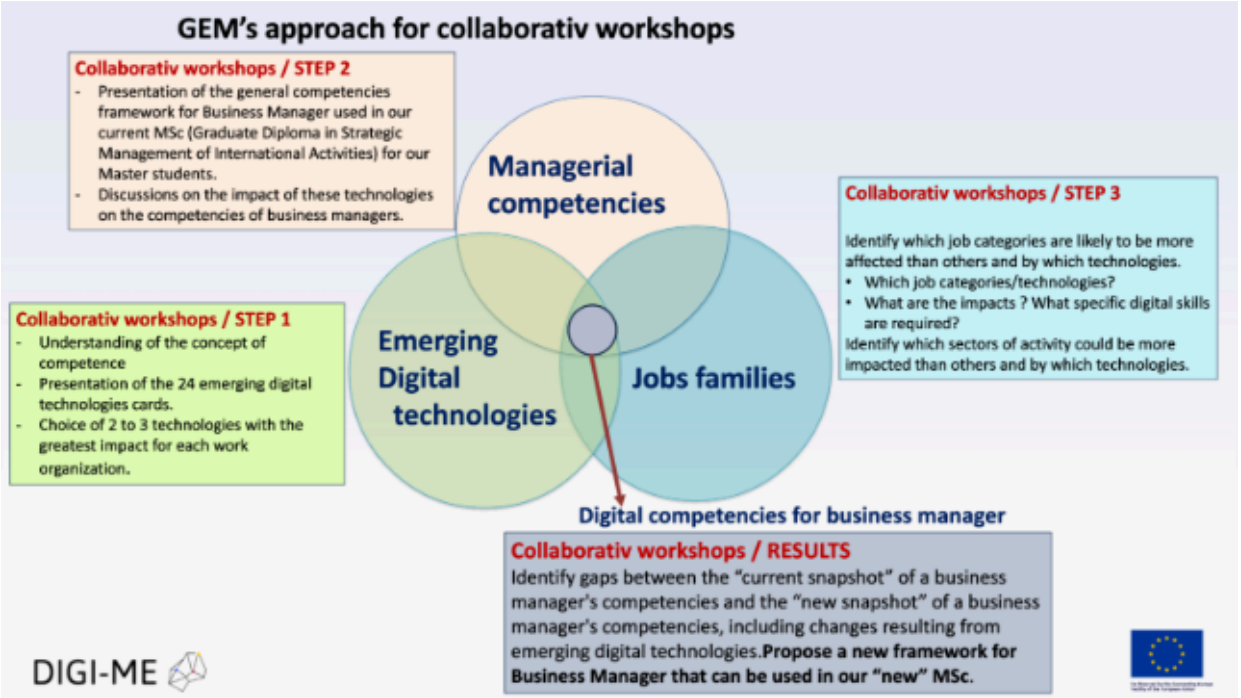


Figure 3. GEM's approach for collaborative workshops

Our approach is based on collective intelligence: discussions, brainstorming, and document analysis.

This section details the initial phase of competency identification for Business Managers within the DIGI ME project. Participants were introduced to a pre-defined competency framework (see definition). To move forward in our thinking and identify the competencies generally expected of a Business Manager, GEM presented the competencies framework of its current master's program: the Master's Degree in Strategic Management of International Activities. This is the framework and degree we want to develop further in the DIGI ME project. The goal of this presentation was to give an example of managerial competencies and show how they are formulated. (see 1.3 Use of the document).

To ascertain the necessary digital competencies for business managers, a targeted approach was employed. Following a presentation outlining 24 emerging digital technologies (detailed in Step 1: Identification of Key Digital Technologies and Skill Development Needs), participants identified those technologies deemed most relevant and impactful to their respective organisations. Subsequently, participants were prompted to reflect upon the specific competencies that business managers must cultivate in response to the transformative effects of these new digital technologies.

The following questions were asked to participants to guide their reflections:

- What tasks or activities will require business managers to develop new competencies?
- Explain how the identified impacts could change, enrich, remove, or replace the manager's tasks or activities.
- Based on GEM's current Business Manager competency framework, which competencies should evolve?
- Should one or more new competencies be added to this framework?

Subsequently, participants were requested to identify business manager job categories that would be most significantly affected, along with the specific technologies driving those changes.

- Which job categories / which technologies?
- What are the impacts? What specific digital skills are required?

A parallel exercise was conducted, focusing on industry sectors and employing a comparable questionnaire.

- Which sectors of activity, based on your experience / which technologies?
- What are the impacts? What specific digital skills are needed?
- Focus on the sectors of activity in our local ecosystem, or even in France.

The information gathered allowed us to identify the gaps between the "current picture" of business manager competencies and the "new picture" of business manager competencies, including changes resulting from emerging digital technologies.

This analysis facilitated our exploration of a revised competency framework for Business Managers, which could be incorporated into our "new" MSc program.

Results:

Step 3: Intelligence Workshop and Preliminary Skills Framework Design. A collective intelligence workshop was held during the consortium meeting in Vaasa on April 10–11, 2025. Each HEI presented its findings from Step 2, contributing to a shared analysis of digital competency needs. The workshop also served to co-develop the core components and structure of the TSF. During this step, the role of our non-HEI partners in the project was particularly valuable in providing insights and feedback on the components of the TSF and how it should evolve. All partners responded to a series of guiding questions (provided in

Annex 3), which enabled the synthesis of skills across different roles, job families, and technology domains.

Step 4: Validation of Skills and Initial Framework Integration. Validation of the proposed digital competencies and the preliminary version of the TSF took place during an in-person meeting in Pavia on June 20, 2025. The partners reached consensus on the core components of TSF v1.1, including the taxonomy of digital competencies to be embedded into the curricula. The meeting also included discussions on how these competencies will be integrated into the master's degree programmes offered within the DIGI-ME. The key findings from this step are provided in the following chapter 3. This marked a critical step in evolving institutional programme models toward more targeted, skills-based offerings.

Step 5, which focuses on training-of-trainers and institutional support for embedding digital skills into teaching practices, will be addressed in a future iteration of the project.

3. Developing the Targeted Skills Framework (version 1.1)

Through the collaborative workshops (see Appendix 3 for one of the workshops as an example) aimed at refining and operationalizing the TSF, the DIGI-ME consortium agreed on five essential components that structure TSF version 1.1:

1. **Job families**
2. **Specializations**
3. **Managerial competencies**
4. **Digital competencies and skills**
5. **Technologies**

This structure reflects both a shared digital skills strategy and the necessary contextualization to individual HEI needs and offerings. Importantly, the following components – job families, specializations, managerial competencies and technologies – are defined as ***local components***. This means they are to be adapted and implemented in ways that align with the specific educational missions, program profiles, and regional ecosystems of each HEI within the DIGI-ME initiative.

Through in-depth discussions and needs analysis, the consortium acknowledged that the DIGI-ME Master's programs slightly vary not only in terms of the disciplinary focus, but also in institutional vision and labour market orientation. Also, the possibilities for adapting programs and developing certifications for lifelong learners are also constrained by each country's specific legal framework. As such, a one-size-fits-all model would neither be

pedagogically sound nor practically viable. Instead, TSF v1.1 encourages differentiation while ensuring alignment through a shared framework for **digital competencies** – or so-called ***global components***.

The figure below illustrates how the five key components of the TSF interrelate:

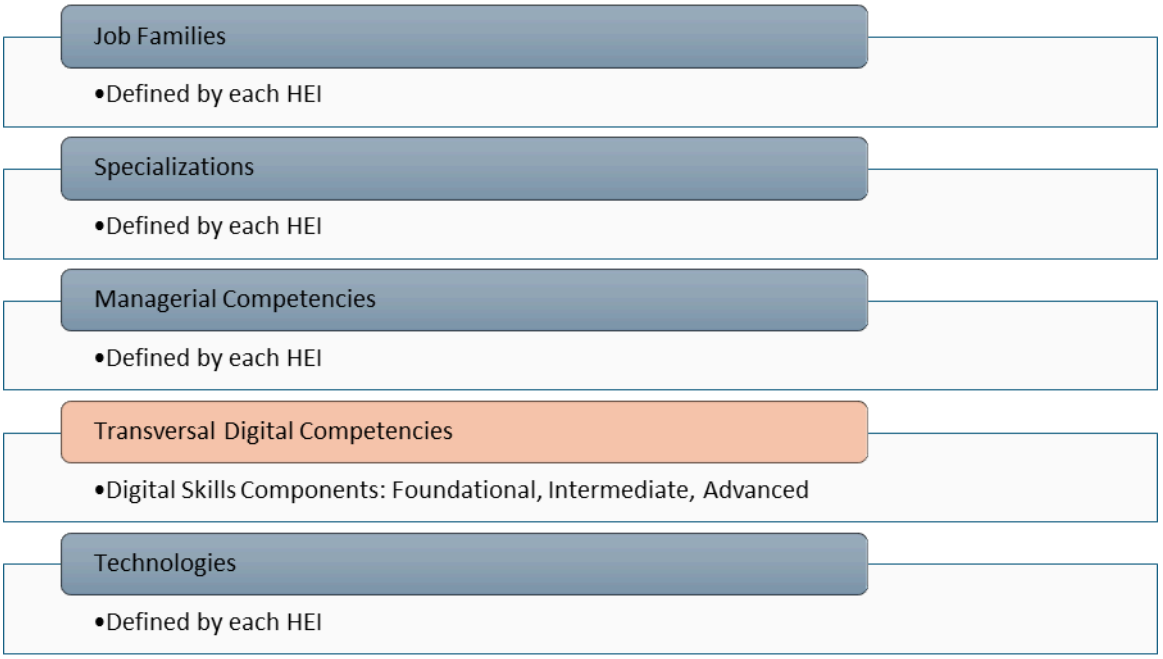


Figure 4. Conceptual structure of TSF v1.1

3.1. Job Families

A job family refers to a broad grouping of related occupations that involve similar types of work and skills (U.S. Office of Personnel Management adopted by EU Skills Panorama, 2018). In the context of the DIGI-ME project, job families were used as an organizing lens to help HEIs align their master's programmes with real-world labour market needs. The following master's programmes were selected as a DIGI-ME offering – University of Vaasa: *Master's Programme in Strategic Business Development* and *Master's Programme in International Business*; University of Pavia: *Master's Programme in International Business and Entrepreneurship* with the specializations in *International Business*, *Digital Transformation & Data Science*, and *Sustainability Management*; for 2025-2026 academic period, Grenoble School of Management has selected *Master's Degree in Strategic Management of International Activities with a specialization in Managing with Data & AI.*

By mapping job families, each HEI was able to identify the professional domains its DIGI-ME offerings support, thereby ensuring relevance and employability for graduates. Incorporating job families into academic programme design enables HEIs to support curriculum integration, where courses are designed not in isolation but as part of a broader professional profile. Furthermore, it assists in lifelong learning pathway development, particularly for non-degree learners or mid-career professionals.

The following table provides an overview of the job families represented across the DIGI-ME HEIs.

Table 7. Current Job families per HEI

EXISTING HEI Programmes selected for DIGI-ME	Current Job Families	Job Family Clusters based on HEIs' information
University of Vaasa: Master's Degree in Strategic Business Development Master's Degree in International Business	▪ Global Strategy & Business Development ▪ Sustainability & CSR ▪ Project & Network Management ▪ Management Consulting	
University of Vaasa: Master's Degree in International Business	▪ International Marketing & Sales ▪ Entrepreneurship & Innovation ▪ Cross-Cultural Management & HRM ▪ Business Research & Analysis	
University of Pavia: Master's Degree in International Business and Entrepreneurship	▪ Entrepreneurship & Business Consulting ▪ International Business ▪ Digital Transformation & Data Science ▪ Sustainability Management	
Grenoble School of Management:	▪ Business Development & marketing ▪ General management	

Master's Degree in Strategic Management of International Activities with a specialization in Managing with Data & AI. (programme selected for 2025-2026)	▪ Strategy ▪ Purchasing ▪ Innovation ▪ HR	

The following figure illustrates the list of job families that are shared among HEIs and those that are unique to a specific institution, reflecting specializations or strategic focus areas.

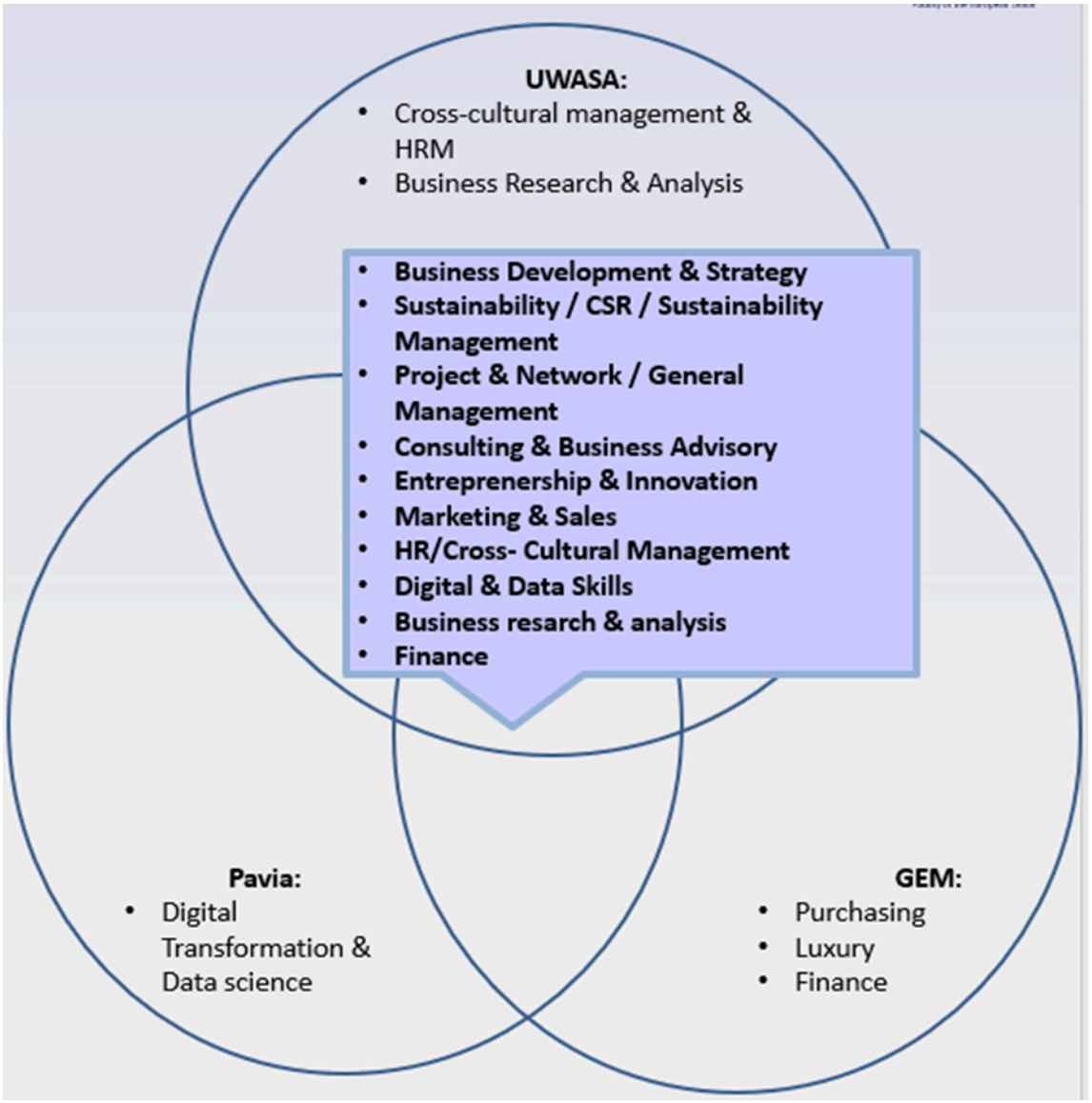


Figure 5. Shared and unique job families

Job families form the foundation of TSF v1.1 by anchoring digital skills development in real-world professional contexts. They provide a shared starting point for cross-HEI dialogue while also allowing for localized differentiation. Their inclusion in the framework ensures that the digital competencies targeted are not abstract, but rather purpose-drive and employment relevant.

3.2. Specializations

Job families give rise to specializations that are more focused areas of expertise within a broader profession. The specializations allow for deeper skill-building and better alignment with niche industry needs or personal career aspirations. As with job families, specializations differ across institutions (detailed list of specializations of job families per HEIs is provided in Annex 4). They reflect both HEIs' academic strengths and their responsiveness to regional economic contexts. The table below illustrates the interlinkages between job families and their associated specializations across HEIs.

Table 8. Current specializations per HEI

Specialization Area	UWASA	GEM	Pavia	Common / Unique
Strategy & Business Development	✔	✔	✔	Common
Sustainability & ESG	✔		✔	Common (only UWASA + Pavia)
Marketing & Sales	✔	✔	✔	Common
Consulting (Management/Business)	✔	✔	✔	Common
Digital / Data / Tech Roles	light	✔	✔	Common (GEM, Pavia), UWASA implied
Entrepreneurship & Innovation	✔		✔	Common (UWASA + Pavia)
HR / Talent Development	✔	✔ (less specific)		UWASA unique depth
Supply Chain / Purchasing		✔	✔ (sustainable focus)	GEM: operational; Pavia: sustainable
Finance / Financial Services	generic	✔	light	GEM strong, UWASA and Pavia less detailed
Legal / Non-Financial Reporting			✔	Unique to Pavia (Governance focus)
Customer Experience / CRM		✔		Unique to GEM
Foresight / Scenario Planning			✔	Unique to Pavia

Specializations ensure that TSF v1.1 is not only relevant but also adaptable. They provide the fine-grained focus necessary for developing meaningful digital and managerial competencies

in context. By preserving specialization diversity, DIGI-ME reinforces the value of different yet interoperable education offerings.

3.3. Managerial Competencies

Managerial competencies form the bridge between specialized technical know-how and the higher-level leadership capabilities required to translate digital opportunities into organizational value. Within TSF v1.1 they occupy an important position, being placed beneath programme design and above the transversal layers of digital competencies and technologies. In other words, they ensure that graduates who possess deep disciplinary knowledge (job families and specializations) can also lead people, projects and transformational initiatives in high-velocity digital contexts.

The managerial competencies embedded in each participating master's programme are summarized in the table below (see Annex 5 for the full matrix and definitions).

Table 8. Current managerial competencies per HEI

University of Vaasa – Strategic Business Development – Managerial Competencies presented as Programme's ILOs	University of Pavia – International Business – Managerial Competencies presented as Programme's ILOs	Current Grenoble School of Management's competency framework for business managers
ILO1: Strategic business development process	ILO1: International strategy formulation	Competency block 1: Drawing up or co-constructing a national and international strategic vision for the company and its application to a business activity
ILO2: Sustainability and ethics in strategic management	ILO2: Trend and market context analysis (economic, legal, socio-cultural)	Competency block 2: Managing extended teams in an international and intercultural context using responsible leadership practices

ILO3: Managerial work in international contexts	ILO3: Entry strategy assessment	Competency block 3: Define the operational priorities for deploying the international strategy within a given business area
ILO4: Problem solving and decision-making skills	ILO4: Cross-cultural marketing and negotiation	Competency block 4: Managing investment choices, operational performance and the risks of international activities with a view to continuous improvement
ILO5: Critical and analytical thinking	ILO5: Scenario planning	Competency Block 5: Manage innovation processes within a given business area
ILO6: Communication skills	ILO6: Soft skills: negotiation, leadership, public speaking	Competency block 6: Conducting and defending in-depth studies of a strategic management topic based on scientific reasoning and highly specialised knowledge
ILO7: Interpersonal skills and teamwork skills	**University of Pavia – Digital Transformation & Data Science – Managerial Competencies presented as Programme's ILOs**	
ILO8: Digital knowledge and skills	ILO1: Digital and data strategy definition	
University of Vaasa – International Business – Managerial Competencies	ILO2: Understanding digital economy dynamics	

presented as Programme's ILOs		
ILO1: Global strategies in a digitized world	ILO3: Leading digital change processes	
ILO2: Global marketing and entrepreneurship	ILO4: Data science and management	
ILO3: Leading people in global business environment	ILO5: Digital marketing, lean management, experiment design	
ILO4: Sustainability and ethics in global business	**University of Pavia – Sustainability Management – Managerial Competencies presented as Programme's ILOs**	
ILO5: Critical thinking, analysis and synthesis	ILO1: Strategic vision on sustainable business practices	
ILO6: Decision making and problem solving	ILO2: Integration of ESG criteria across value chain	
ILO7: Business research and analysis	ILO3: Non-financial reporting and sustainability assessment	
ILO8: Cross-Cultural communication and negotiation skills	ILO4: Circular economy and responsible innovation	
ILO9: Collaboration in diverse teams	ILO5: Stakeholder engagement and impact evaluation	
ILO10: Self-management	ILO6: Leadership in sustainability-oriented transformation	

	ILO7: Soft skills: ethical decision-making, communication, team collaboration	

Although the information presented in Table 8 above regarding current managerial competencies at GEM is provided at a more general level, a number of key observations can be made about the managerial competencies embedded in each participating Master's programme, particularly those at the University of Vaasa and the University of Pavia. First, a shared core is evident across all HEIs with strategic thinking, change management, ethical leadership and stakeholder communication forming the foundation. Second, the depth of digital integration varies. For example, while some programmes such as the University of Pavia's Digital Transformation & Data Science explicitly embed digital competencies, others reference digitalization only implicitly. Lastly, the analysis highlights clear gaps and opportunities, especially in programmes where digital elements are lightly mentioned. In these cases, there is significant potential to enhance curricula with specific digital competencies to better reflect evolving labour market expectations.

Managerial competencies are the lever through which the TSF translates specialized knowledge into real-work impact. Ensuring that these competencies explicitly incorporate digital dimensions will be critical for the next iteration (v1.2).

3.4. Digital Competencies and Skills

The foundational reference point for the digital competencies and skills in this iteration of TSF v1.1 is the most recent update of the Digital Competence Framework for Citizens (DigComp 2.2) (Furtáková, 2024; Vuorikari et al., 2022), which provides a comprehensive structure to define, assess, and apply digital competences in diverse educational and professional settings. The selection of DigComp 2.2 as the foundational model for TSF v1.1 is justified by its robustness, wide acceptance across Europe, and adaptability to various learning contexts. It includes five competence areas: 1) information and data literacy, 2) communication and collaboration, 3) digital content creation, 4) safety, and 5) problem solving. Each competence area is further broken down into detailed descriptions, examples of knowledge, skills, and attitudes, and three levels of proficiency (foundation, intermediate, advanced). To ensure a comprehensive view, earlier DigComp iterations were also reviewed, namely DigComp 2.1 (Carretero et al., 2017), DigComp 2.0 (Vuorikari et al., 2016), and the

original DigComp 1.0 (Ferrari, 2013), each contributing to an evolving understanding of digital competence relevant to both citizens and educators.

In adapting DigComp to the DIGI-ME project context, the consortium triangulated findings from several source:

- The initial Targeted Skills Framework (TSF v1.0) presented in Deliverable D1.1 (January 2025),
- A systematic literature review conducted by the University of Pavia (Annex 2),
- Workshops hosted by University of Vaasa, University of Pavia, and Grenoble School of Management with industry stakeholders (methodology in Chapter 2; summary findings in Annex 6).
- The EU AI Act that entered phased implementation from 2025 onward.

These activities revealed both alignment and gaps between DigComp and the digital competencies required in the programs under the DIGI-ME offering. *DigComp was therefore not adopted wholesale, instead it was used as a foundational framework, which was then contextualized and extended based on project-specific findings*.

While DigComp 2.2 organises its framework around five dimensions – competence areas, proficiency levels, knowledge/skills/attitudes, examples of use, and purposes of application – the DIGI-ME version (TSF v1.1) employs three dimensions to increase clarity and usability:

1. Competence Area
2. Specific Skills
3. Proficiency Levels (discussed in detail in Section 3.4.1)

Dimensions 4 (examples of use) and 5 (purposes of application) will be considered in future iterations of the TSF based on input from teaching staff, program managers, and DETI company partners in the next project phases.

The table below illustrates targeted digital competencies and skills that are part of TSF v1.1. Detailed definitions of each competence and skill are provided in Annex 7.

Table 9. Digital competencies and skills

Digital Competencies	Digital Skills	Source
1. Information and Data literacy	1.1. Browsing, searching and filtering data, information and digital content	DigCopm; Needs Analysis; GEM DETI Workshop; Pavia

	1.2. Evaluating data, information and digital content	SLR; Vaasa DETI Workshop; the EU AI Act
	1.3. Managing data, information and digital content	
	*1.4 Reflective trust in digital systems based on data, modeling, and ethical standards	
2. Communication and Collaboration	2.1. Interacting through digital technologies	DigComp; Needs Analysis; GEM DETI Workshop; Pavia SLR; Vaasa DETI Workshop
	2.2. Sharing through digital technologies	
	2.3. Engaging citizenship through digital technologies	
	2.4. Collaborating through digital technologies	
	2.5. Netiquette	
	2.6. Managing digital identity	
	*2.7 Facilitating human and machine interaction and collaboration in hybrid environments	
	*2.8 Cooperating and collaborating across functions	
3. Digital Content Creation	3.1. Developing digital content	DigComp; Needs Analysis; GEM DETI Workshop; Pavia SLR; Vaasa DETI Workshop
	3.2. Integrating and re-elaborating digital content	
	3.3. Copyright and licenses	
	3.4. Programming	
4. Safety	4.1. Protecting devices	DigComp; Needs Analysis; GEM DETI Workshop; Vaasa DETI Workshop; the EU AI Act
	4.2. Protecting personal data and privacy	
	4.3. Protecting health and well-being	
	4.4. Protecting the environment	
	*4.5. Evaluating ethical risks and regulations in tech integration	
5. Problem Solving	5.1. Solving technical problems	DigComp; GEM DETI Workshop; Pavia SLR; Vaasa DETI Workshop
	5.2. Identifying needs and technological responses	
	5.3. Creatively using digital technology	
	5.4. Identifying digital competence gaps	

*6. Emerging Technology Integration	*6.1 Optimizing emerging tech use in operations	Needs Analysis; GEM DETI Workshop; Pavia SLR; Vaasa DETI Workshop; the EU AI Act
	*6.2 Evaluating technology maturity and usage, and associated risk categories	
	*6.3 Identifying integration challenges and success factors	
*7. Digital Self-Development and Reflective Practice	*7.1 Engaging in reflective practice to assess and improve digital and managerial competence.	Needs Analysis; GEM DETI Workshop; Vaasa DETI Workshop

*In red are highlighted competencies and skills that emerged from Needs Analysis, Workshops, & Systematic Literature Review and not earlier defined in DigComp

This version of the TSF v.1.1 offers a significant step forward in aligning digital competencies with the realities of modern managerial and sectoral contexts. By building on the strong structure of DigComp and enriching it with findings from literature, empirical stakeholder engagement, and practical program-level needs, the TSF v1.1 introduces a targeted, adaptable, and future-oriented model of embedding digital competencies into higher education curricula.

Furthermore, to ensure the design of the TSF is aligned with European standards and policy goals, a comprehensive needs analysis and competency mapping were conducted to identify digital skills requirements and existing gaps (results provided in Deliverable D1.1, submitted 31.01.2025). That process draws on key European frameworks and policy instruments, including the **DigComp**, European Skills, Competencies, Qualifications and Occupations (**ESCO)**, the **European e-Competence Framework (e-CF),** European Qualifications Framework (**EQF**). The alignment between TSF and the **EU AI Act** was conducted in the latest version of the TSF v1.1.

DigComp was used as a starting point for the comprehensive understanding of the digital skills identified so far. ESCO was then applied to map core digital skills into the category of role-specific digital skills and cross-cutting skills that our TSF aims to illustrate, considering that the offered digital competencies are primarily designed for business leaders. The e-CF framework ensured that the TSF is coherent with EU digital policy objectives, transparent in terminology, and adaptable to the rapidly evolving technological and regulatory landscape. The EQF was further referenced to contextualize proficiency levels and support comparability across education and training systems.

The EU AI Act informed the ethical, governance, and compliance dimensions of the TSF, ensuing that emerging competencies related to data use, automation, and AI integration reflect the principles of trustworthy and human-centric AI.

3.4.1. Proficiency Levels

To support the pedagogical implementation of the TSF v1.1, three proficiency levels are proposed for each digital competence: Foundation, Intermediate, and Advanced. This three-level structure aligns with established digital competence frameworks, particularly those developed under the DigComp (Ferrari, 2013; Carretero et al., 2017; Vuorikari et al., 2022; Furtáková, 2024), and is rooted in the European Qualification Framework (EQF) levels, which promote transparency, progression, and comparability of learning outcomes across educational systems in Europe.

These proficiency levels are not simply defined by technical skills but also by increasing Complexity, Autonomy, Responsibility, and Impact of digital competence application. Each level also incorporates cognitive depth, using action verbs adapted from Bloom's Taxonomy (Anderson & Krathwohl, 2001) to help educators and program managers in formulating Intended Learning Outcomes (ILOs) that are both measurable and scalable across diverse learning contexts. The table below provides overview of proficiency levels.

Table 10. Overview of proficiency levels

	Level of complexity	Complexity of tasks	Autonomy	Cognitive domain (Bloom)	Example
Foundation	Level 1	Simple tasks	With guidance	Recognizing, listing, remembering, identifying, finding, describing	Learner demonstrates basic understanding of digital tools and concepts
	Level 2	Simple tasks	Autonomy and with guidance	Recognizing, listing, remembering, identifying,	Learner demonstrates basic understanding of

			where needed	finding, describing	digital tools and concepts; applies known solutions in familiar contexts
Intermediate	Level 3	Well-defined and routine tasks, and straightforward problems	On my own	Understanding, explaining, integrating, comparing	Learner adapts and applies digital competencies to diverse contexts
	Level 4	Tasks, and well-defined and non-routine problems	Independent and according to the needs	Understanding, illustrating, organizing, describing, applying, interpreting, evaluating	Learner adapts and applies digital competencies to diverse contexts; begins to evaluate and solve problems independently
Advanced	Level 5	Different tasks and problems	Guiding others	Responding, proposing, critiquing, transforming	Learner critically selects, designs, or leads

					digital solutions in complex or novel contexts; demonstrates strategic use of digital skills in leadership or innovation roles
	Level 6	Most appropriate tasks	Able to adapt to others in a complex context	Evaluating, assessing, adapting, designing, leading, transforming	Learner critically selects, designs, or leads digital solutions in complex or novel contexts; mentors or guides others

Program managers and teachers can use this model to tailor Intended Learning Outcomes (ILOs) that integrate digital dimensions. For instance, a foundation-level ILO may require students to *identify cybersecurity risks in each scenario*, whereas an advanced-level ILO could ask students to *design and implement a digital risk mitigation strategy across departments*. This approach acknowledges that digital proficiency is not static, but rather contextually dynamic and shaped by technological change, learner motivation, and evolving

workplace demands. It also provides a foundation for further development of formative and summative assessment criteria, digital micro-credentialing, and cross-program recognition of learner achievements.

3.5. Technologies

The final component of TSF v1.1 addresses the technological landscape shaping the digital competencies and skills in contemporary business education and practice. The integration of technologies in the framework ensures that learners are not only digitally literate but also capable of navigating, evaluating, and leading in technologically intensive environments.

To identify the most relevant technologies, a triangulated approach was adopted. This included data from stakeholder workshops conducted by HEI partners, as well as a systematic literature review (see Annex 2) and a consolidated list of Key Emerging Technologies (Annex 1). Stakeholders were invited to reflect on technologies that are currently transforming their business operations and those expected to be most influential in the near future. This collaborative process resulted in the identification of 29 technologies that are central to TSF v1.1.

Table 11. Technologies identified through the workshops and literature review

Technologies identified through University of Vaasa's Workshops	Technologies identified for TSF v1.1
AI agents and enhanced software engineering Prompt Engineering Security Against Misinformation Risk assessment of AI and digital systems Business intelligence platforms, hybrid/private cloud migration Process optimization tools and intelligent automation Virtual reality Digital Twins Human-Teach interface technologies	1. Edge Computing and 6G for Real-Time Analysis 2. Advanced AI 3. IoT 4. Process Mining Platform 5. Prompt Engineering 6. Decision Intelligence Platforms 7. Green Software Development 8. Neurosymbolic AI 9. Security Against Misinformation 10. Blockchain and Distributed Ledger Technology for Management 11. AI TRiSM (AI Trust, Risk, and Security Management) 12. Quantum Computing
Technologies identified through University of Pavia's Literature Review	
Virtual reality Artificial intelligence Digital learning platforms Augmented reality	

Machine learning Generative AI	13. AI-powered Software Engineering 14. Virtual Reality 15. Artificial Intelligence 16. Digital Learning Platforms 17. Augmented Reality 18. Machine Learning 19. Generative AI 20. Digital Twins 21. Quantum Computing & AI Supercomputers 22. Augmented and Virtual Reality in the Workplace 23. Machine Customers 24. Brain-Machine Interface for Cognitive Enhancement 25. AI Agents and Enhanced Software Engineering 26. Risk Assessment of AI and Digital Systems 27. Business Intelligence Platforms, Hybrid/Private Cloud Migration 28. Process Optimization Tools and Intelligent Automation 29. Human-Teach Interface Technologies
Technologies identified through University of Pavia's Workshops	
Advanced AI Neurosymbolic AI Digital Twins Quantum Computing & AI Supercomputers Augmented and Virtual Reality in the Workplace Edge Computing and 6G for Real-Time Analysis Machine Customers Brain-Machine Interface for Cognitive Enhancement	
Technologies identified through GEM's Workshops	
Advanced AI: 4 occurrences Edge computing: 3 occurrences Prompt engineering: 3 occurrences Green software development: 3 occurrences IoT: 2 occurrences Process mining platforms: 2 occurrences AI TRiSM (AI Trust, Risk, and Security Management): 2 occurrences Security against misinformation: 2 occurrences Quantum computing: 2 occurrences Decision intelligence platforms: 2 occurrences Blockchain: 2 occurrences Neurosymbolic AI AI-powered software engineering Agent based AI Digital twins Process Mining	

While TSF v1.1 incorporates these technologies primarily at the level of awareness and strategic reflection, future iterations of the framework will offer detailed mappings of technologies to specific digital skills, competencies, and pedagogical use cases. This will enable educators and program designers to integrate technology-specific learning outcomes, case studies, and learning pathways more systematically into business education curricula.

In conclusion, by embedding technology as a dynamic and evolving component of the framework, TSF v1.1 supports future-oriented learning and ensures alignment with industry

demands, pedagogical innovation, and the ethical use of digital systems in management practice.

4. Planned Integration of the TSF v1.1 into Master's Programmes

This chapter outlines the intended integration of the TSF v1.1 into the master's programmes selected for the DIGI-ME offer across the participating higher education institutions (HEIs) in the DIGI-ME project, illustrating the value-added element of the TSF in this project. The integration process builds the refined methodology and is closely aligned with the broader goals of enhancing digital education offerings within business-oriented graduate programmes. The TSF v1.1 provides a structured set of digital competencies and proficiency levels designed to guide programme redesign, curriculum development, and instructional planning, with a specific emphasis on personalization and responsiveness to labour market needs.

During the collective intelligence workshop (Step 3 of the methodology), four primary user groups for the TSF were identified: educators/programme managers, students, lifelong learners, and employers. In the current implementation of TSF v1.1, the primary focus is on educators and programme managers, reflecting the immediate priorities of the DIGI-ME project in WP3, namely the enhancement of master's degree programmes and the training of academic staff.

The integration of TSF into HEI curricula can occur at varying depths, ranging from minimal adjustments, such as benchmarking existing curricula against the framework, to more extensive interventions, such as the revision of intended learning outcomes (ILOs) at both the programme and course levels. At the most advanced level, TSF is used to define individualized proficiency pathways for students and to identify support structures necessary for developing specific digital competencies. This tiered model of application is illustrated in the figure provided below.

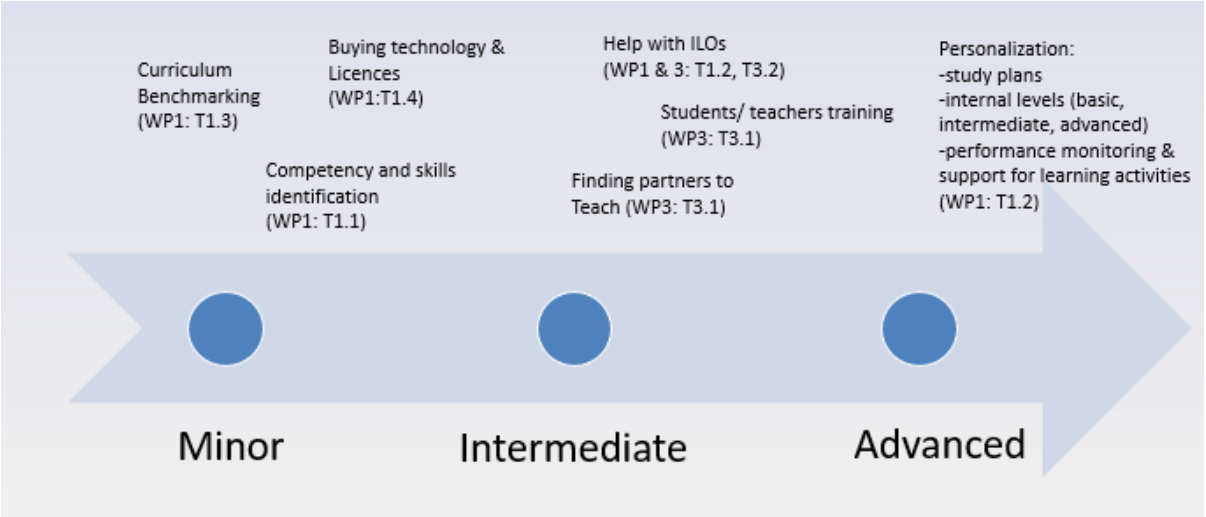


Figure 6. Application of TSF to enhance HEI's Programmes

The following sections detail how each partner HEI intends to apply TSF v1.1 in practice.

4.1. Integration of the TSF v1.1 at the University of Vaasa

At the University of Vaasa, the integration of TSF v1.1 will be implemented to strengthen the digital dimension of two master's programmes that are part of the DIGI-ME offer: the *Master's Degree in International Business* and the *Master's Degree in Strategic Business Development*. The integration process will follow a structured sequence of actions that ensures alignment between the TSF digital competencies and the academic goals of each programme. This process involves five key stages: (1) reviewing existing programme and course ILOs, (2) meeting with programme managers and teachers, (3) presenting TSF v1.1 to co-develop revised ILOs, (4) identifying personalization and proficiency levels for digital competencies, and (5) assessing and delivering the support necessary for implementation.

In the Strategic Business Development programme, a review of existing programme-level ILOs reveals a broad and somewhat ambiguous formulation of digital learning outcomes (ILOs of the programme are summarized in the table below). ILO8 states that students should demonstrate the "ability to identify new trends of organizational digitalization in terms of digitalized processes, technologies and types of applications relevant for implementing digital transformation in strategic management." While this signals an intention to address digital topics, it lacks specificity in terms of the competencies and proficiency levels students are expected to acquire.

Table 12. Current ILOs of the Master's Degree in Strategic Business Development

Intended Learning Outcomes (ILOs)	Name	Description
ILO 1	Strategic business development process	Ability to plan and implement comprehensive business development processes in various contexts by using frameworks and tools of strategic management
ILO 2	Sustainability and ethics in strategic management	Ability to recognize the key aspects of strategic management vital in promoting sustainability and ethical management and conduct strategic business planning accordingly
ILO 3	Managerial work in international contexts	Ability to manage business development processes in multicultural teams, international projects, international, organizations, international business networks and global markets
ILO 4	Problem solving and decision-making skills	Ability to creatively solve problems concerning economic, business and managerial issues in various contexts
ILO 5	Critical and analytical thinking	Ability to search and use information, approach issues from various angles, differentiate between important and non-important issues, and use consistent logic in one's own argumentation
ILO 6	Communication skills	Ability to express themselves orally and in written form in working life situations of one's own field. Students also should possess good abilities for giving presentations in public

ILO 7	Interpersonal skills and teamwork skills	Ability to work with different people and understand the principles behind working effectively in teams and be able to function as responsible members of a team
ILO 8	Digital knowledge and skills	Ability to identify new trends of organizational digitalization in terms of digitalized processes, technologies and types of applications relevant for implementing digital transformation in strategic management. Digital skills in using certain basic applications

Following a presentation of TSF v1.1 to the programme manager, a more precise and actionable ILO8 will be co-developed, for example: *"Demonstrates the ability to identify and critically assess trends in organizational digitalization, including digitalized processes, technologies, and applications for strategic transformation. Applies data and information literacy, collaborates and communicates through digital tools, ensures digital safety and ethical awareness, and engages in reflective practice to enhance digital and managerial competencies."* This revised ILO is more robust in that it maps directly onto specific domains and sub-domains within the TSF v1.1 framework, thereby making the expected outcomes more transparent and measurable.

Subsequent steps will involve meetings with course instructors to examine how digital competencies can be embedded into course-level ILOs (illustrative figure is provided below). For instance, in the course *Sustainability and Business Ethics*, the original ILOs lack any explicit reference to digital competencies. After familiarizing themselves with TSF v1.1, the instructors might propose incorporating aspects of data ethics and digital safety into the curriculum. Specifically, two competencies might be prioritized: (1) Information and Data Literacy (1.2 Evaluating data, information and digital content), and (2) Safety (4.5 Evaluating ethical risks and regulations in tech integration). As a result, a new ILO might be added: *"Critically evaluate the credibility, relevance, and impact of digital data and information used in sustainability and ethical decision-making, and assess ethical risks and regulatory implications related to the integration of digital technologies in business practices."*

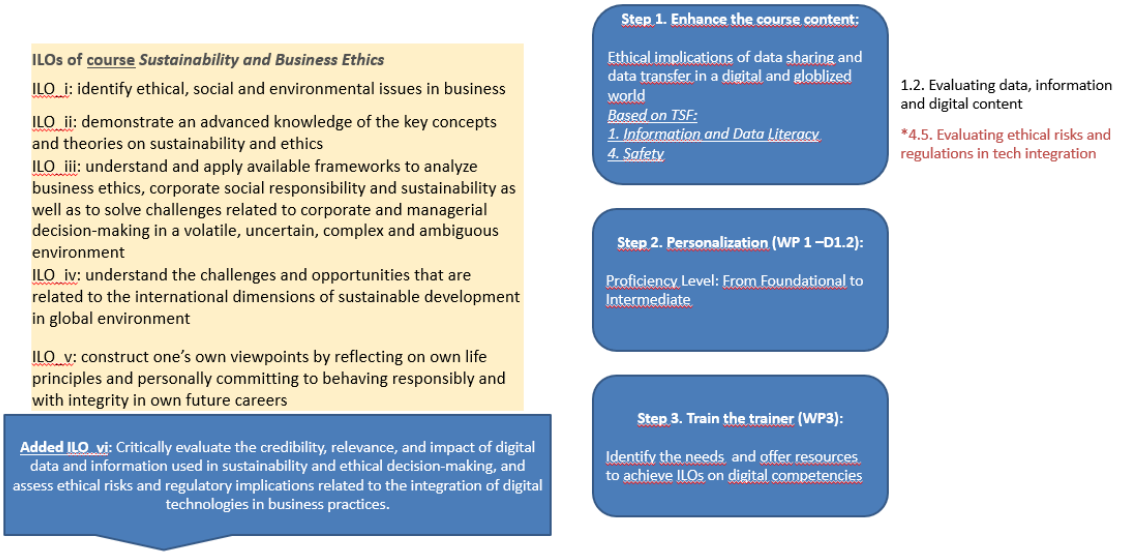


Figure 7. Application of TSF v1.1 to enhance a DIGI-ME course (SBD programme)

This addition not only strengthens the alignment between the course and broader programme goals but also enables a more personalized learning experience by establishing proficiency targets ranging from foundational to intermediate levels for the digital competencies addressed. In this initial phase of integration, TSF will be also used to identify resource needs, including instructional materials and pedagogical support, to ensure the successful implementation of the revised ILOs.

A parallel process is underway in the International Business programme (the programme's ILOs are summarized in the table below). While a review of programme-level ILOs identified that ILO1 titled "Global strategies in a digitized world" addresses the theme of digital transformation, it lacks concrete operationalization in terms of competencies and learning objectives. Through collaborative engagement with the programme manager and subsequent presentation of TSF v1.1, this ILO can be reformulated as follows: *"Students will demonstrate advanced knowledge of globalization strategies and the ability to develop global digital business strategies by effectively analyzing and managing digital information, collaborating and communicating across digital platforms, creating strategic digital content, applying digital problem-solving skills, and evaluating safety, privacy, and ethical considerations in global digital environments."*

Table 13. Current ILOs of the Master's Degree in International Business

Intended Learning Outcomes (ILOs)	Name	Description
ILO 1	Global strategies in a digitized world	Demonstrate an advanced knowledge of the key concepts and theories in globalization strategies and how to develop global digital business strategies
ILO 2	Global marketing and entrepreneurship	Demonstrate an advanced knowledge of the key concepts and theories in global marketing strategies and entrepreneurial growth in an uncertain and complex global environment
ILO 3	Leading people in global business environment	Demonstrate an advanced knowledge of the key concepts and theories in global human resource management and leadership, how to create plans to support the employees' competences and performance and how to develop global leadership
ILO 4	Sustainability and ethics in global business	Demonstrate an advanced knowledge of the key concepts and theories on sustainability and ethics and the challenges and opportunities which are related to the integration of economic, social and environmental dimensions of sustainable development in global business
ILO 5	Critical thinking, analysis and synthesis	Capability to identify assumptions, evaluate statements in terms of evidence, to detect false logic or reasoning, to identify implicit values, to define terms adequately and to generalize appropriately
ILO 6	Decision-making and problem solving	Capability to identify business problems and opportunities in a volatile, uncertain, complex and ambiguous global environment and solve them for sustainable global business using appropriate methods such as research, co-operation and networking

ILO 7	Business research and analysis	Capability to gather primary and secondary data, analyse, evaluate and apply research findings into practice and / or decision making in global context
ILO 8	Cross-cultural communication and negotiation skills	Communicate and negotiate effectively in oral and written form both in physical and digital environment in cross-cultural setting
ILO9	Collaboration in diverse teams	Work effectively in cross-cultural teams both as a team member and as a leader respecting the talents and beliefs of others regardless of their background
ILO10	Self management	Ability to set priorities and to allocate time efficiently in order to meet deadlines, take initiatives, constantly developing practices and internalising routines for maximising one's ability to deal with the uncertainty of an ever-changing environment and plan personal and career development

This revised ILO builds a clearer connection to TSF domains such as Communication and Collaboration, Digital Content Creation, and Safety. Meetings with course instructors will be used to cascade these changes into the course-level ILOs. For instance, in the *Global Marketing Management* course, the instructor might plan to integrate several competencies from TSF v1.1, including (2.1) Interacting through digital technologies, (2.2) Sharing through digital technologies, (2.4) Collaborating through digital technologies, and (2.8) Cooperating and collaborating across functions. This will lead to a new ILO, for example: *"Students will demonstrate the ability to interact, share, and collaborate effectively through digital technologies in global marketing contexts, including cross-functional cooperation to co-create marketing strategies in diverse and digitally connected environments"* (illustrative figure is provided below).

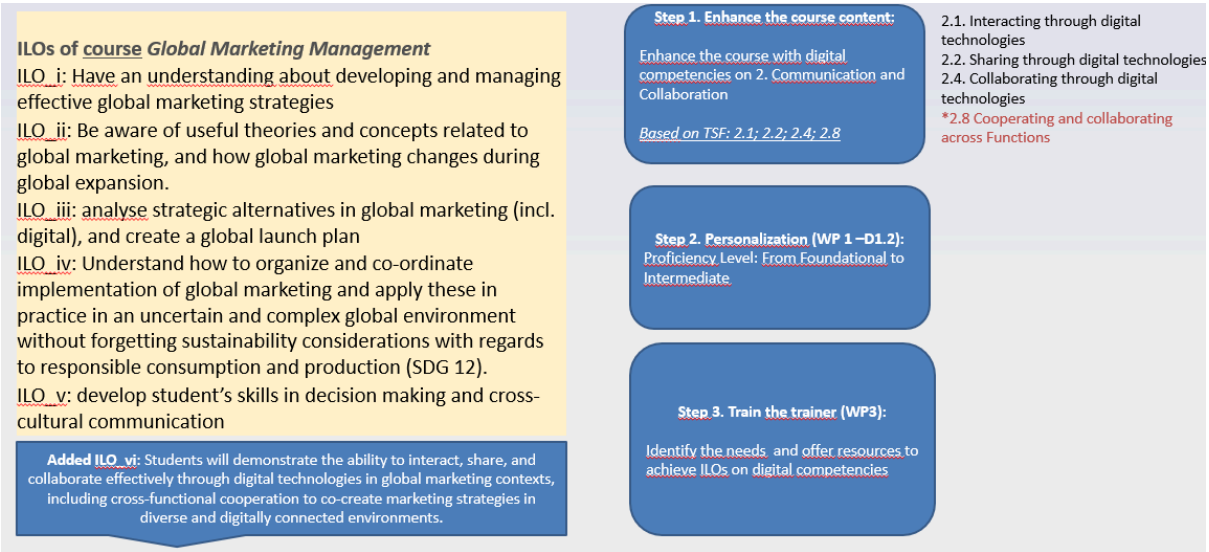


Figure 8. Application of TSF v1.1 to enhance a DIGI-ME course (MIB programme)

As in the previous example, the personalization of learning will be supported through the designation of foundational to intermediate proficiency levels, and resources will be identified to ensure that course delivery supports students in achieving these revised outcomes.

Through this process, the University of Vaasa illustrates how TSF v1.1 can be pragmatically applied to enhance the relevance, clarity, and effectiveness of Master's programmes. By strengthening the articulation of digital competencies and embedding them in course-level outcomes, the institution is taking concrete steps toward delivering a more future-oriented and personalized educational experience. This aligns well with the overarching goals of DIGI-ME in preparing learners for the challenges and opportunities of digitally transformed work environments.

The planned integration process ensures that TSF v1.1 becomes an actionable tool in WP 3 for curricular innovation, moving beyond abstract frameworks into tangible enhancements in programme design, course delivery, and learning assessment.

4.2. Integration of the TSF v1.1 at the University of Pavia

At the University of Pavia, the integration of TSF v1.1 is planned to enhance the digital dimension of the Master's Degree in International Business & Entrepreneurship (MIBE). This integration will be carried out through a comprehensive and iterative process, with

progressive modifications implemented and evaluated on an annual basis to ensure ongoing alignment with the core objectives of the DIGI-ME project. Implementation will begin in the 2025–2026 academic year, informed by the outcomes of TSF v1.1 and future versions.

The integration will consider the three main specializations offered within the MIBE program:
a) International Management
b) Digital Management
c) Sustainability Management

As part of this initiative, the MIBE program will introduce new modules designed to develop advanced digital skills essential for managerial competencies. These modules will be informed by insights from the conducted workshops, the SLR, and feedback from external experts and assessments. The table below presents a structured overview of the proposed courses. For each course, a corresponding set of Intended Learning Outcomes (ILOs) is outlined as follows:

Table 14. ILOs of the MIBE program.

Course Title	Intended Learning Outcomes (ILOs)	Digital competencies/skills
Digital Product Innovation and Artificial Intelligence	- Understand the principles of digital product innovation and lifecycle management. - Apply AI techniques to enhance product development and customer experience. - Evaluate the impact of emerging digital technologies on innovation strategies.	1. Information and Data Literacy ▪ 1.2 Evaluating data, information, and digital content ▪ 1.4 Reflective trust in digital systems based on data, modeling, and ethical standards 6. Emerging Technology Integration ▪ 6.1 Optimizing emerging tech use in operations

		▪ 6.2 Evaluating technology maturity and usage
Digital Health	- Explain the role of digital technologies in modern healthcare systems. - Analyze ethical, legal, and privacy concerns in digital health initiatives. - Design patient-centered digital health solutions using current technologies.	4. Safety ▪ 4.2 Protecting personal data and privacy ▪ 4.3 Protecting health and well-being 6. Emerging Technology Integration ▪ 6.2 Evaluating technology maturity and usage 7. Digital Self Development ▪ 7.1 Engaging in reflective practice to improve digital competence
Strategic Foresight for the Digital Age	- Apply foresight methods to anticipate digital transformation trends. - Develop strategic scenarios to inform decision-making in uncertain environments. - Assess the impact of digital innovation on long-term business and societal models.	5. Problem Solving ▪ 5.2 Identifying needs and technological responses ▪ 5.3 Creatively using digital technology 6. Emerging Technology Integration ▪ 6.3 Identifying integration challenges and success factors
Governance 5.0 – Cross Digitalization of ESG, GRC and Finance Processes	- Integrate ESG (Environmental, Social, Governance) principles into digital governance frameworks. - Analyze how digitalization	4. Safety ▪ 4.5 Evaluating ethical risks and regulations in tech integration

	transforms risk, compliance, and financial processes. - Design governance models aligned with Industry 5.0 principles and sustainability goals.	6. Emerging Technology Integration ▪ 6.2 Evaluating technology maturity and usage
Advanced Digital Technologies in Sustainable Management and Reporting	- Evaluate the use of AI, IoT, and blockchain in sustainable business practices. - Apply digital tools to enhance transparency in environmental and social reporting. - Design data-driven strategies for sustainable performance management.	1. Information and Data Literacy ▪ 1.2 Evaluating data, information, and digital content 6. Emerging Technology Integration ▪ 6.1 Optimizing emerging tech use in operations 7. Digital Self Development ▪ 7.1 Reflective practice to improve competence
Digital Marketing	- Understand digital marketing strategies and tools across different platforms. - Create and evaluate digital campaigns using data analytics. - Apply user behavior insights to optimize digital customer engagement.	1. Information and Data Literacy ▪ 1.1 Browsing, searching and filtering data ▪ 1.3 Managing data, information and digital content 2. Communication and Collaboration ▪ 2.7 Facilitating human-machine interaction

		3. Digital Content Creation ▪ 3.1 Developing digital content ▪ 3.2 Integrating and re-elaborating digital content

Moreover, also already existing MIBE modules can be added to the DIGI-ME offer delivering some lectures on the adoption of advanced digital skills for managerial competencies, while other existing MIBE modules will continue to be rolled out to MIBE students.

The Added Value of TSF v1.1 in the Context of MIBE's DIGI-ME Offerings

The integration of the TSF v1.1 within the MIBE programme represents a significant advancement in aligning the master's curriculum with the evolving demands of the digital age. As part of the DIGI-ME initiative, the TSF v1.1 offers strategic benefits that directly enhance MIBE's educational model. Thus, this integration allows the MIBE programme to ensure that its curriculum is directly aligned with the real-world digital skills needs of companies, institutions, and entrepreneurs. This alignment not only enhances the relevance of the program but also improves graduate employability by addressing the evolving landscape of job families, roles, specializations, and the associated digital and managerial competencies. Furthermore, the ongoing assessment of the TSF and the integration of future versions will ensure that the educational offering remains up to date, responding effectively to the continuous and rapid evolution of technology in this field.

4.3. Integration of the TSF v1.1 at Grenoble School of Management

At Grenoble Ecole de Management, the integration of TSF v1.1 can occur at multiple levels. The implementation remains constrained by the applicable legal framework for French higher education and GEM's internal procedures for program development and training offer design.

From the competency-based approach to the applicable legal framework for French higher education:

It was particularly important that the refined methodology introduced in Deliverable D1.1 (January 2025) be based on the competency-based approach. In effect, the competency-based approach, as conceived in education sciences, is a pedagogical framework centered on the development and validation of tangible abilities.[1] It aims to equip learners with coherent sets of knowledge, skills, attitudes, and autonomy that can be mobilized in various situations. Instead of merely acquiring theoretical knowledge, this approach emphasizes practical application, experimentation, and problem-solving in authentic or simulated contexts.

It rests on precisely defining the competencies to be achieved, adopting practice-oriented teaching methods, and implementing assessments focused on the student's ability to apply their skills in real-world situations. This ensures training that meets professional standards and better prepares learners for their entry into the workforce.

This competency-based approach is essential in the design of Master's programs within French regulations. Within the context of French higher education, especially for awarding Master's degrees, this approach is now a core element of the regulatory framework.[2] National reference frameworks, along with the European Qualifications Framework (e.g., LMF/QCF), guide the design of curricula. These programs must be structured around clearly defined professional competencies that reflect labour market needs and societal expectations.

Specifically, this means that:

- Curriculum development must enable students to acquire, develop, and master a set of competencies with precise pedagogical objectives.
- Teaching methods are adapted to promote practical application through projects, internships, real-world tasks, or simulations.
- Assessment methods are reoriented to verify that students have mastered these competencies in concrete contexts, rather than merely reproducing theoretical knowledge.

This regulatory framework aims to ensure that a Master's degree certification attests not only to academic knowledge but also to tangible operational skills aligned with professional requirements.

[1] Makulova, A. T., Alimzhanova, G. M., Bekturganova, Z. M., Umirzakova, Z. A., Makulova, L. T., & Karymbayeva, K. M. (2015). Theory and practice of competency-based approach in education. *International Education Studies*, *8*(8), 183-192.
[2] Poumay, M. (dir.) (2022). Comment mettre en œuvre une approche par compétences dans le supérieur ? De Boeck Supérieur. https://doi.org/10.3917/dbu.tardi.2022.01.

Grenoble Ecole de Management is a “Grande École” and not a university. For the design and evolution of its degrees, it must follow the procedure established by CEFDG to obtain authorization to award a degree recognized by the French government (master's degree).

The French Management Education Accreditation Committee (CEFDG) plays a key role in validating Master’s programs developed by Grandes Écoles. It relies on a process that is fundamentally based on the competency-based approach to evaluate the quality and conformity of these programs.

Practically, CEFDG verifies that the program is built around a clear set of professional competencies. It examines whether the content, pedagogical approach, and assessment methods allow students to acquire and validate these competencies under conditions close to those of the labour market.

The evaluation also focuses on the overall coherence between program structure, pedagogical implementation, and the ability to develop students' competencies to a level consistent with international standards. The goal of this process is to ensure that the Master’s degree issued by the Grande École legitimately attests to tangible, operational, and professionally relevant skills, in compliance with national regulations and market expectations.

In summary, this approach ensures that a Master’s program does not merely provide academic training but produces graduates capable of acting effectively in their future professional environments.

GEM's project: to develop a new competencies framework to enhance our MSc program and incorporate TSF v1.1.

During the two series of collaborative workshops organized by GEM, we used the current competencies framework of our Master in Strategic Management of International Business as a basis for identifying the competencies to be retained, those to be modified, and the new digital competencies that a business manager must acquire.

One of the outcomes of these workshops was the launch of a project aiming at enhancing the current Master reference competences framework with novel digital skills, internally labeled: “Business Manager for Responsible Techno-Digital Transformation - Digi-Me". To appreciate the contribution of DIGI-ME to the development of the underlying competences framework, both the current framework and the project are presented in full in the appendices. (Appendix 5 & Appendix 6)

The competencies presented in this project of new competencies framework are structured into 10 homogeneous blocks, each of which makes sense independently of the others. The numbering is only used to locate the blocks and competencies. These 10 blocks reflect the points highlighted during the workshops we conducted with companies. Block 7 is particularly important: “Mobilize expertise in an emerging technology and its ecosystem with regard to its strategic implications.” This block should enable learners to develop expertise in specific technologies, as emergent from the development of the local DETI network (WP2).

The competencies are formulated in such a way as to cover professional situations without going into too much detail. No specific technologies are mentioned, as this is not necessary. The aim is for the framework to remain relatively stable over time, between 2 and 3 years. The technologies are to be specified in the learning objectives.

The purpose of this reference framework is to serve as a basis for developing our various training offerings: programs and certifications. In addition, this draft new skills framework is linked to TSF v1.1, which it has helped to enrich. TSF v1.1 is integrated into the new framework by specifying the digital skills that make up certain competencies.

We have therefore been able to clarify this link in a table below.

Table 15. Integration of TSF v1.1 into GEM’s offering

Blocks of competencies		Targeted digital skills V1.1
Competency block 1: Co-organize economic, geopolitical, technological, and digital monitoring for an organization and its ecosystem.	Identify monitoring priorities in line with the company's strategic positioning, integrating CSR and ethical dimensions to guide and optimize the organization and resources allocated to monitoring.	1.1 Browsing, searching and filtering data 1.2 Evaluating data 1.3 Managing data
	Identify formal and informal sources to ensure the quality of the information gathered	
	Organize the monitoring process, defining tools and schedules according to	

	changes in the environment and the organization's needs.	
	Report to the relevant departments on trends, threats and opportunities to be monitored in relation to the parent organization, in order to integrate this information and analysis into strategic choices.	
Competency block 2: Define an organization's strategy in the face of the transformative potential of technology, digitalization, and CSR.	Characterize the ecosystem in which the organization operates in order to seize opportunities and minimize risks, and identify resources and networks.	5.2 Identifying needs and technological responses. 6.1 Optimizing emerging tech use in operations. 6.2 Evaluating technology maturity and usage 6.3 Identifying integration challenges and success factors 7.1 Engaging in reflective practice 2.3 Engaging citizenship through digital technologies 4.4 Protecting the environment
	Assess the organization's technological, digital, and CSR maturity in order to take these elements into account when identifying strategic options and challenges, based on the levels and practices observed within the sector.	
	Lead or co-lead the development of an international strategic vision by setting objectives and ensuring meaningful alignment, while considering the economic, social, and ethical impacts of decisions.	
	Examine the value creation model and the types of performance indicators	

	used, to support decision-making—particularly in light of technological, digital, CSR, and ethical challenges.	
Competency block 3. Assess an organization's financial situation and investment capacity.	Analyze the cash flow statement to assess the company's financial health.	1.3 Managing data 5.1 Solving technical problems 1.4 Reflective trust in digital systems based on data, modeling, and ethical standards
	Analyze key financial ratios (profitability, liquidity, working capital and working capital requirements, debt, return on investment, etc.) to inform strategic decision-making.	
Competency block 4: Adapt team management to new organizational structures.	Facilitate team collaboration by optimizing collective intelligence processes and human/machine hybridization across tasks and activities, while ensuring the inclusion of diverse employee profiles.	2.4 Collaborating through digital technologies 2.1 Interacting through digital technologies 2.2 Sharing through digital technologies 2.7 Facilitating human/machine interaction in hybrid environments 4.3 Protecting health and well-being
	Support change management by integrating new work structures and team management approaches to evolve practices in alignment with necessary adaptations and the chosen business model.	
	Manage the specific leadership challenges associated with multidisciplinary teams	

	composed largely of technoscientific profiles.	
	Advise and negotiate with both teams and business partners in intercultural contexts, while upholding ethical and professional standards.	
Competency block 5: Communicate with multidisciplinary teams on managerial and technoscientific topics.	Develop self-awareness (action and communication styles, etc.) by regularly engaging in reflective practices regarding professional and managerial actions, and by assessing skills in light of the evolution of the profession, tools, organization, and society, in order to define areas for improvement.	3.2 Integrating and re-elaborating digital content 5.3 Creatively using digital technology 5.2 Identifying needs and technological responses 2.6 Managing digital identity 2.5 Netiquette
	Adapt both written and oral communication, with the help of new digital tools, to different stakeholders and professional contexts (meeting facilitation, interviews, arguments in interpersonal or group situations) to ensure clear messaging and maintain the desired quality of relationships.	
	Understand the main characteristics of problem-solving approaches, sizing, and simulation/evaluation	

	methods used by engineers, as well as the key tools, in order to foster constructive exchanges.	
Competency block 6: Define the operational areas, processes, and tools for deploying the strategy within a specific scope of activities.	Identify the specific rules and standards for the activity and professions within the defined scope in order to establish the required safeguards and implementation guidelines, including re-evaluating existing organizational structures and processes, and updating the necessary skills.	1.3 Managing data 6.1 Optimizing emerging tech use in operations 6.3 Identifying integration challenges and success factors 4.2 Protecting personal data and privacy 3.3 Copyright and licenses
	Implement policies, processes, and practices that translate strategic directions and priorities into action plans, incorporating AI tools.	
	Optimize the use of data systems and technologies (IS, blockchain, AI, etc.) in operations management, ensuring attention to ethics, standards, and legal frameworks.	
	Anticipate crisis situations by structuring and organizing appropriate crisis management processes.	
Competency block 7: Mobilize the expertise of an emerging technology and its ecosystem in terms of its strategic implications.	Characterize the maturity and usage of technology.	6.1 Optimizing emerging tech use in operations 6.2 Evaluating technology maturity and usage
	Define the technology ecosystem, including its key	

	specialists and development centers.	6.3 Identifying integration challenges and success factors
	Inventory the main challenges of its integration and identify key success factors.	5.4 Identifying digital competence gaps 3.4Programming 4.4 Protecting the environment
	Assess the CSR and ethical risks and opportunities of the technology, along with regulatory constraints, compared to one or more use cases.	3.3 Copyright and licenses 4.5 Evaluating ethical risks and regulations in tech integration
Competency block 8: Drive investment decisions, operational performance, and risk management of international activities using data and new technologies, with a focus on continuous improvement.	Evaluate investment opportunities and their profitability in relation to the proposed strategy.	
	Manage both financial and non-financial indicators to guide operational activities specific to the relevant professions and functions, assessing the effects and results of the action plans undertaken.	1.3 Managing data 5.1 Solving technical problems 4.2 Protecting personal data and privacy 5.3 Creatively using digital technology
	Determine priorities and risk management approaches based on risk mapping and qualifications, in order to reduce the exposure of the business and its activities to those risks.	4.1 Protecting devices
Competency block 9: Deploy innovation	Promote and lead innovation processes within	5.2 Identifying needs and technological responses

processes tailored to the technological and societal characteristics of the project.	the scope of activity, in alignment with the company's innovation policy.	3.1 Developing digital content 3.2 Integrating and re-elaborating digital content 6.1 Optimizing emerging tech use in operations
	Define and manage innovation projects according to methods, processes, and tools suited to the technologies and sectors involved.	
	Foster entrepreneurial leadership practices, rather than managerial approaches, to promote innovation and transformation.	
Competency block 10: Conduct and defend in-depth studies on a strategic management topic based on scientific reasoning and highly specialized knowledge	Identify, select, and critically analyze various sources of highly specialized knowledge to document a topic and synthesize this data for its exploitation.	7.1 Engaging in reflective practice 1.2 Evaluating data
	Define and address a strategic management issue by applying a scientific approach, resources, methodologies, and reasoning in order to produce a written document with structured, in-depth, and reliable analysis, offering original proposals for the activity, company, or sector.	
	Defend, in writing, the proposed analysis and chosen approach before various audiences,	

	convincing them of the conclusions and recommendations, in either French or a foreign language.	

The integration process will follow a structured, phased approach, comprising the following key stages:

4.3.1 Stakeholder Engagement (Expected Autumn 2025)

- **Meetings with the Academic and Programs Director** will be organized in preparation for the launch of the new competencies framework, *"Business Manager for Responsible Techno-Digital Transformation"*, scheduled for the 2026–2027 academic year.
- **Meetings with the Executive Education Director** will focus on the development of certifications targeting lifelong learners, with the objective of launching initial offerings by the end of 2025. The certification design will be informed by the new competencies framework and further refined through workshops with DETI ecosystem organizations. The modular "building blocks" for certification will be developed in parallel with the stages of curriculum development outlined below.

4.3.2 Validation with Program Managers and Curriculum Co-Development

Engagement with specialization program managers will ensure validation and alignment of the project, including the presentation of the *Business Manager for Responsible Techno-Digital Transformation* framework and TSF v1.1. This co-development phase will facilitate the revision and adaptation of curricula.

To operationalize the transition from competencies framework to actionable training objectives and course structures, the following steps are recommended:

To operationalize the transition from competencies to actionable training objectives and course structures the following steps will be followed [3] :

[3] Département Formation et emploi, Insertion Professionnelle de la DGESIP - Ministère de l'Enseignement Supérieur et de la Recherche. (2024, mars). *Guide pratique : articuler le RNCP à une approche par compétence*. https://www.enseignementsup-recherche.gouv.fr/sites/default/files/2024-06/articuler-le-rncp-une-approche-par-comp-tences---guide-pratique-2024-33373.pdf

Certification Assessment: Define assessment mechanisms that validate the acquisition of one or more competencies in a block through one or more exams.

Critical Learning Identification: Clarify the essential learning elements required for effective competency acquisition, in consultation with business professionals to ensure relevance and alignment with industry needs.

Prerequisite Definition: Based on the "typical learner profile" (e.g., a student with a management science foundation entering a master's program), specify prerequisite knowledge, methods, tools, and attitudes necessary to achieve the intended learning objectives. For example, requiring foundational knowledge in economics before enrollment in a sector analysis module.

Formulation of Learning Objectives: Translate competencies into precise learning objectives detailing the knowledge, methods, tools, and attitudes learners must acquire within each competency block. These objectives should reference TSF v1.1 and be developed collaboratively with faculty members specialized in each discipline, including the identification of personalization and proficiency levels for digital competencies.

Specialization Orientation by Function or Sector: Enable the development of specialization pathways derived from the competency framework, tailored to specific functions (e.g., marketing, sales) or sectors (e.g., energy), aligned with the DETI ecosystem's priorities.

Inventory of Existing Courses and Integrative Learning Formats: Identify current courses that contribute to the targeted competencies, including integrative modules such as hackathons, use cases, and project-based activities that support competency development.

Identification of Gaps and Development of New Learning Resources: Map gaps in the current offerings and determine the development of new courses, scenarios, and integrative learning formats (e.g., additional hackathons, case studies) necessary to fully address the competency framework.

4.3.3 Implementation Support

In this phase, targeted support will be provided for the implementation of the new framework, including:

- Training sessions for pedagogical teams, both for permanent faculty and adjunct instructors, to ensure effective delivery of the revised programs.

- Structured discussions with teaching teams on leveraging resources from DETI ecosystem partners, including specialist contributions and real-world use cases (link with WP3), to enrich program delivery.

For GEM, the structured process outlined above will facilitate the adaptation of master's programs and specialization offerings in alignment with TSF v1.1 and the new digital competency framework for business managers. Additionally, it will support the development of certification pathways for lifelong learners, reinforcing GEM's positioning within the evolving techno-digital education landscape.

Table 16. Summary of the implementation activities at GEM

Phase	Activities	Objectives
1. Stakeholder Engagement (Expected Autumn 2025)	▪ Meetings with the Academic and Programs Director to prepare the launch of the *Business Manager for Responsible Techno-Digital Transformation* competency framework (2026–2027). ▪ Meetings with the Executive Education Director to develop certification pathways for lifelong learners, leveraging the new competency framework and DETI workshops.	▪ Secure leadership alignment and strategic sponsorship. ▪ Define certification "building blocks" aligned with curriculum development.
2. Validation and Co-Development with Program Managers	▪ Present the competency framework and TSF v1.1 to program managers. ▪ Co-develop revised curricula and specialization pathways.	▪ Transition from competencies to actionable training objectives and courses. ▪ Ensure program relevance and

		alignment with DETI priorities.
Curriculum Development Steps *(within Phase 2)*	▪ Define certification assessment mechanisms. ▪ Identify critical learning requirements with industry input. ▪ Define prerequisites based on learner profiles. ▪ Formulate learning objectives referencing TSF v1.1. ▪ Identify specialization opportunities by function/sector. ▪ Map existing courses and integrative modules contributing to competencies. ▪ Identify gaps and design new courses, scenarios, and modules.	▪ Operationalize the competency framework into structured, modular learning paths. ▪ Support personalization and proficiency-level mapping for digital competencies.
3. Implementation Support	▪ Train pedagogical teams (faculty and adjuncts) for program delivery. (WP3) ▪ Coordinate with DETI partners for resource integration (expert input, use cases).	▪ Enable effective implementation of revised programs and certifications. ▪ Foster collaboration with the DETI ecosystem for practical integration.

5. Future Steps for TSF

Building on the progress achieved in this iteration, the consortium will take a phased and collaborative approach to further refine the TSF. The next steps align with the DIGI-ME work package structure and leverage the mobility plans and stakeholder partnerships already in place.

The following table summarizes the future steps towards TSF integration and iteration.

Table 17. Future steps for TSF

Focus Area	Key Activities (2025-2026)	Lead WP	Expected Outputs
Curriculum Integration & Course Enhancement	▪ Map TSF v1.1 to individual course syllabi across all DIGI-ME Master's programmes. ▪ Co-design personalization and assessments that operationalize the new digital competencies at Foundation, Intermediate and Advanced levels. ▪ Identify gaps in faculty digital capability; develop	WP1, WP3	▪ Course-level ILOs aligned to TSF v1.1. ▪ Faculty-development roadmap and resource bank.

	tailored support (training, peer mentoring, digital toolkits).		
Mobility Pathways (Single, Double, Triple Diploma)	▪ Harmonize TSF learning outcomes across partner HEIs to ensure credit recognition. ▪ Embed the three proficiency levels into joint course modules offered during mobility periods. ▪ Pilot digital micro-credentials that travel with students across institutions.	WP3	▪ Prototype micro-credential framework (badge taxonomy, assessment rubrics).
Certification for Non-Degree Learners	▪ Translate selected TSF competencies into short courses and micro-credentials for lifelong learners. ▪ Establish recognition pathways between non-degree credentials and degree credit.	WP3	▪ Certificate catalogue linked to TSF.

Ongoing DETI Partner Engagement	▪ Use TSF v1.1 as a discussion artefact with DETI companies for continuous labour-market validation. ▪ e.g., University of Vaasa will host an open workshop at the Vaasa Future Festival (August 2025) to launch a Digital Innovation & Sustainability Lab (WP 2) where DETI partners can co-create case studies, capstone projects, and technology roadmaps.	WP2	▪ Annual DETI feedback report on digital-competence relevance. ▪ Repository of co-created teaching cases
Methodology & Framework Evolution	▪ Integrate DigComp Dimensions 4 & 5 (examples of use/purposes) into the next iterations where feasible. ▪ Monitor emerging technologies and update the TSF technology list annually.	WP1, WP2, WP3	▪ TSF v1.2 with updated dimensions and technology mappings. ▪ Methodology refinement paper for conference/journal submission.

These future steps ensure that TSF remains a living framework, continuously validated by industry, enriched through cross-institutional mobility, and extended to lifelong learners through certified pathways.

6. References

Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman.

Carretero, S., Vuorikari, R., & Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use*. Publications Office of the European Union. https://doi.org/10.2760/38842

Cedefop. (2020). *Vocational education and training in Europe 1995–2035: Scenarios for European vocational education and training in the 21st century*. Publications Office of the European Union.

Council of the European Union. (2018). *Council Recommendation on Key Competences for Lifelong Learning (2018/C 189/01)*. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018H0604(01)

Département Formation et emploi, Insertion Professionnelle de la DGESIP - Ministère de l'Enseignement Supérieur et de la Recherche. (2024, mars). Guide pratique : articuler le RNCP à une approche par compétence. https://www.enseignementsup-recherche.gouv.fr/sites/default/files/2024-06/articuler-le-rncp-une-approche-par-comp-tences---guide-pratique-2024-33373.pdf

European Commission. (2008). *European Qualifications Framework for lifelong learning (EQF)*. Publications Office of the European Union. https://europa.eu/europass/en/european-qualifications-framework-eqf

European e-Competence Framework (e-CF). (2019). *A common European framework for ICT professionals in all industry sectors*. CEN. https://www.ecompetences.eu

Ferrari, A. (2013). *DIGCOMP: A framework for developing and understanding digital competence in Europe*. JRC-IPTS, Publications Office of the European Union. https://doi.org/10.2788/52966

Furtáková, T. (2024). *DigComp Framework: From 1.0 to 2.2. Quo Vadis Community.*

Gartner. (2025). *Hype cycle for emerging technologies 2025*. Gartner, Inc.

Gartner. (2025). *Adoption radar 2025: A visual representation of emerging technologies*. Gartner, Inc.

OECD. (2018). *The future of education and skills: Education 2030 – The future we want*. OECD Publishing. https://www.oecd.org/education/2030/

OECD. (n.d.). *OECD Learning Compass 2030: A framework for student learning outcomes*. Retrieved from https://www.oecd.org/education/2030-project/

Poumay, M. (dir.) (2022). Comment mettre en œuvre une approche par compétences dans le supérieur ? De Boeck Supérieur. https://doi.org/10.3917/dbu.tardi.2022.01.

Tardif, J. (2006). *L'évaluation des compétences*. Documenter le parcours de développement. Montréal : Chenelière Éducation https://www.cahiers-pedagogiques.com

U.S. Office of Personnel Management. (n.d.). *Federal workforce competency model*. Adapted by EU Skills Panorama. Retrieved from https://skillspanorama.cedefop.europa.eu & https://www.opm.gov/policy-data-oversight/classification-qualifications/classifying-general-schedule-positions/occupationalhandbook.pdf

Vosloo, S. (2018). *Digital literacy and sustainable development*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000265533

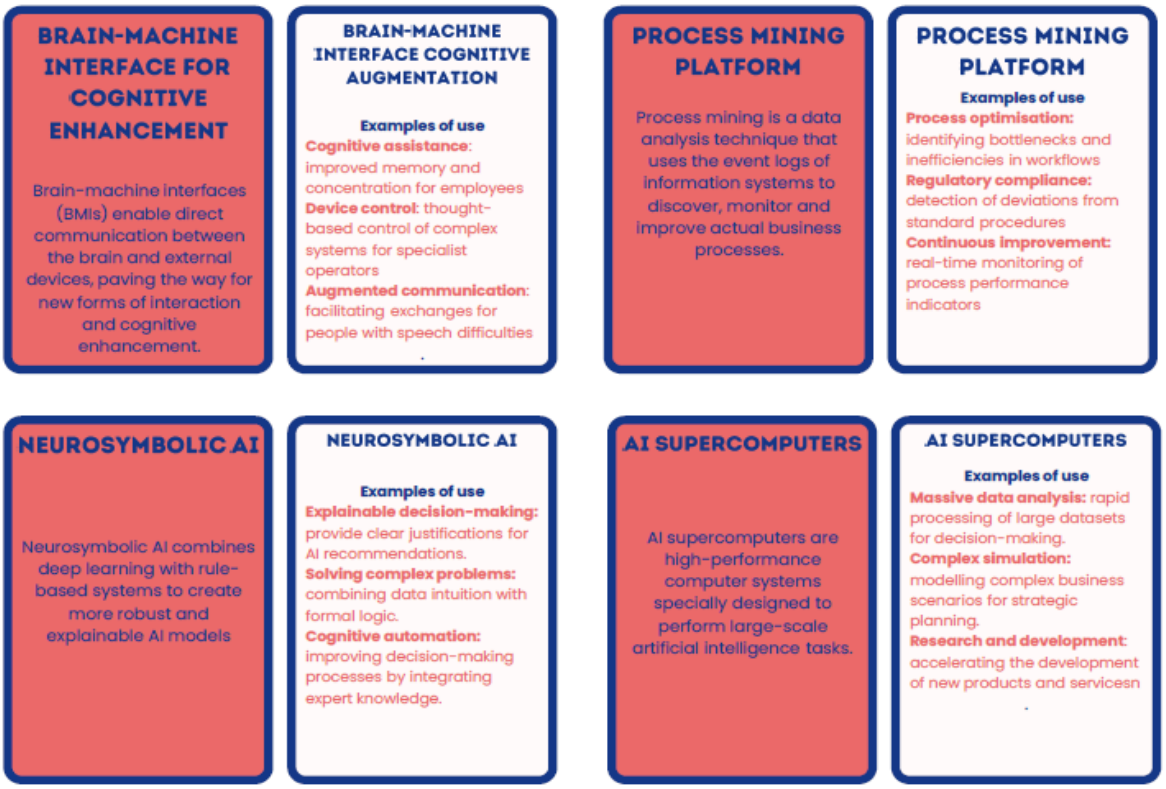
Vuorikari, R., Carretero, S., Punie, Y., & Van den Brande, G. (2016). *DigComp 2.0: The Digital Competence Framework for Citizens – Update Phase 1*. Publications Office of the European Union. https://doi.org/10.2791/11517

Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens – With new examples of knowledge, skills and attitudes*. Publications Office of the European Union. https://doi.org/10.2760/115376

7. Appendices

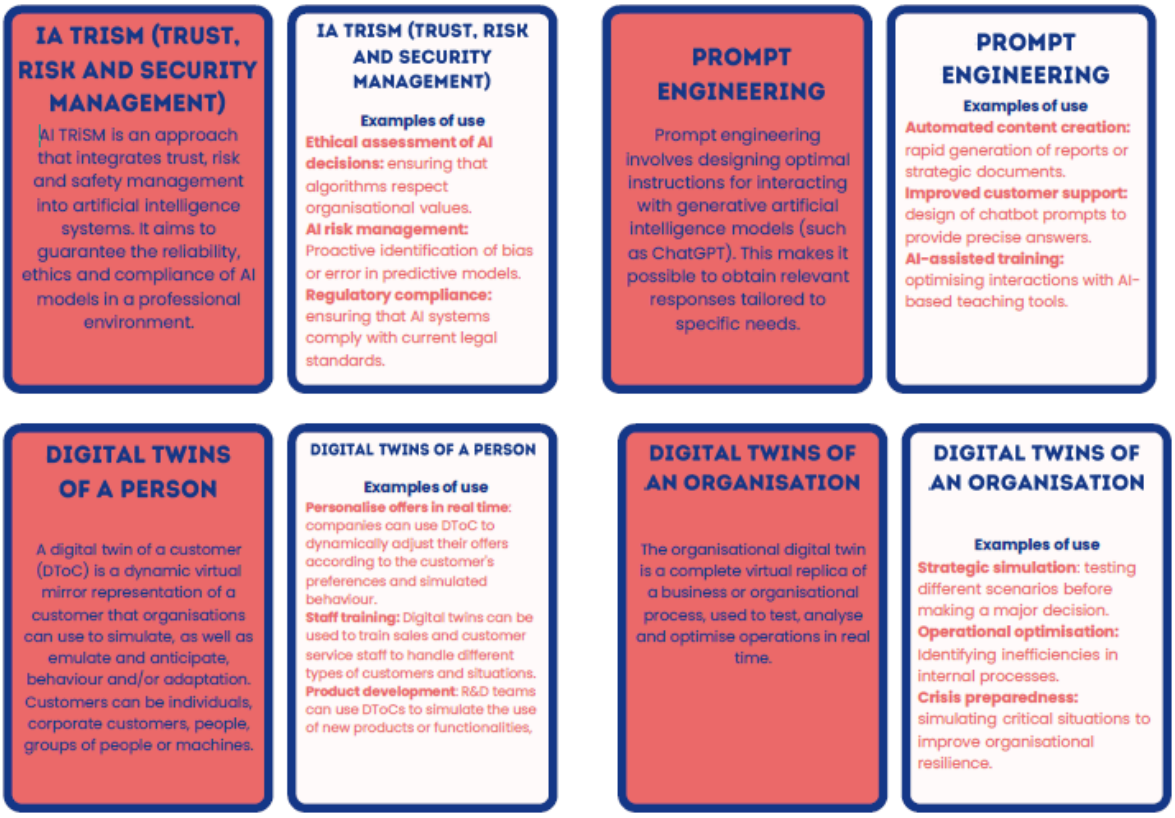
Appendix 1. Key Emerging Technologies and Methodology for Their Identification


ADVANCED AI
Advanced AI brings together technologies that enable machines to reproduce complex human cognitive functions such as voice recognition, planning and decision-making. It is mainly divided into weak AI (dedicated to specific tasks) and strong AI (hypothetical, capable of autonomous reasoning).
ADVANCED AI
Examples of use
Customer service: intelligent chatbots capable of solving complex problems
Human resources: predictive analysis for recruitment and talent management
Marketing: real-time personalisation of offers based on customer behaviour
INDUSTRIAL INTERNET OF THINGS (IIOT)
IIoT refers to the application of the Internet of Things in the industrial context. It involves the interconnection of sensors, devices and machines to collect and analyse data in real time, enabling industrial processes to be optimised.
INDUSTRIAL INTERNET OF THINGS (IIOT)
Examples of use
Predictive maintenance: real-time monitoring of machines to anticipate breakdowns
Production optimisation: automatic adjustment of manufacturing parameters
Supply chain management: real-time monitoring of stocks and deliveries
AUGMENTED AND VIRTUAL REALITY IN THE WORKPLACE
Augmented reality superimposes digital information on the real world, while virtual reality immerses the user in an entirely digital environment.
AUGMENTED AND VIRTUAL REALITY IN THE WORKPLACE
Examples of use
Training: interactive visual guides for learning new tasks
Maintenance: augmented reality instructions for technicians in the field
Collaboration: virtual meetings with interactive 3D object sharing
DIGITAL TWINS
A digital twin is a virtual representation of a physical object or system, used for real-time simulation, monitoring and optimisation.
DIGITAL TWINS
Examples of use
Predictive maintenance: anticipating breakdowns in industrial equipment
Product design: virtual testing and optimisation before physical production
Urban management: modelling and optimising traffic and energy flows in smart cities
QUANTUM COMPUTING
Quantum computing is a multidisciplinary field that uses quantum mechanics to solve complex problems faster than conventional computers. It exploits quantum phenomena such as superposition and interference to perform calculations.
QUANTUM COMPUTING
Examples of use
Finance: optimising investment portfolios and risk analysis
Logistics: solving complex routing problems for vehicle fleets
Pharmaceutical R&D: molecular simulation for the development of new drugs
EDGE COMPUTING AND 6G FOR REAL-TIME ANALYSIS
Edge computing is a decentralised IT architecture that processes data as close as possible to its source, while 6G is the next generation of mobile networks offering ultra-fast speeds and extremely low latency.
EDGE COMPUTING AND 6G FOR REAL-TIME ANALYSIS
Examples of use
Autonomous vehicles: instant processing of sensor data for decision-making
Smart factories: real-time optimisation of production processes
Telemedicine: remote diagnosis with immediate analysis of medical data
STAND-ALONE SYSTEMS
Autonomous systems are machines or software capable of operating and making decisions without direct human intervention, by adapting to their environment.
STAND-ALONE SYSTEMS
Examples of use
Transport: autonomous vehicles for logistics and passenger transport
Industry: collaborative robots capable of working safely alongside humans
Agriculture: autonomous drones to monitor crops and apply targeted treatments
BLOCKCHAIN AND DISTRIBUTED LEDGER TECHNOLOGY FOR MANAGEMENT
Blockchain is a secure and transparent system of distributed registers, enabling reliable transactions and data exchanges without a central intermediary.
BLOCKCHAIN AND DISTRIBUTED LEDGER TECHNOLOGY FOR MANAGEMENT
Examples of use
Supply chain: full traceability of products from origin to delivery
Smart contracts: automating commercial and legal processes
Identity management: securing and controlling personal data in companies


BRAIN-MACHINE INTERFACE FOR COGNITIVE ENHANCEMENT
Brain-machine interfaces (BMIs) enable direct communication between the brain and external devices, paving the way for new forms of interaction and cognitive enhancement.
BRAIN-MACHINE INTERFACE COGNITIVE AUGMENTATION
Examples of use
Cognitive assistance: improved memory and concentration for employees
Device control: thought-based control of complex systems for specialist operators
Augmented communication: facilitating exchanges for people with speech difficulties
PROCESS MINING PLATFORM
Process mining is a data analysis technique that uses the event logs of information systems to discover, monitor and improve actual business processes.
PROCESS MINING PLATFORM
Examples of use
Process optimisation: identifying bottlenecks and inefficiencies in workflows
Regulatory compliance: detection of deviations from standard procedures
Continuous improvement: real-time monitoring of process performance indicators
NEUROSYMBOLIC AI
Neurosymbolic AI combines deep learning with rule-based systems to create more robust and explainable AI models
NEUROSYMBOLIC AI
Examples of use
Explainable decision-making: provide clear justifications for AI recommendations.
Solving complex problems: combining data intuition with formal logic.
Cognitive automation: improving decision-making processes by integrating expert knowledge.
AI SUPERCOMPUTERS
AI supercomputers are high-performance computer systems specially designed to perform large-scale artificial intelligence tasks.
AI SUPERCOMPUTERS
Examples of use
Massive data analysis: rapid processing of large datasets for decision-making.
Complex simulation: modelling complex business scenarios for strategic planning.
Research and development: accelerating the development of new products and servicesn


BUSINESS INTELLIGENCE PLATFORMS
These platforms use AI and advanced analytics to improve and automate decision-making in organisations
BUSINESS INTELLIGENCE PLATFORMS
Examples of use
Resource optimisation: intelligent allocation of resources based on accurate forecasts
Risk management: proactive identification of potential risks in operations
Customer personalisation: adapting offers and services to customers' needs in real time
INTELLIGENT ROBOTS
Intelligent robots are autonomous machines capable of interacting with their environment and learning from their experiences thanks to AI.
INTELLIGENT ROBOTS
Examples of use
Warehouse automation: optimising stock management and logistics.
Employee assistance: man-machine collaboration for complex tasks.
Customer service: advanced conversational robots for 24/7 customer support.
MACHINE CUSTOMERS
Client machines are AI systems capable of acting as autonomous consumers, making purchases and transactions without direct human intervention.
MACHINE CUSTOMERS
Examples of use
Automated procurement: Intelligent purchasing systems for stock management.
Predictive marketing: Anticipating the needs of machine customers to adapt the offering.
Supply chain optimisation: automatic coordination between purchasing and sales systems.
GREEN SOFTWARE DEVELOPMENT
This approach aims to create software that is more energy-efficient and environmentally-friendly.
GREEN SOFTWARE DEVELOPMENT
Examples of use
Cost reduction: optimising the energy consumption of IT systems.
Social responsibility: integrating sustainable practices into product development.
Ecological innovation: Creation of software solutions to support environmental initiatives.


CLOUD AR (AUGMENTED REALITY)
Cloud AR enables augmented reality data to be stored and processed in the cloud, providing richer, more accessible AR experiences
CLOUD AR (AUGMENTED REALITY)
Examples of use
Distance learning: creating immersive learning environments for employees
Virtual collaboration: meetings and presentations in AR for geographically dispersed teams
Data visualisation: interactive representation of complex data for decision-making.
SECURITY AGAINST MISINFORMATION
This area focuses on protection against the spread of false information and the manipulation of public opinion.
SECURITY AGAINST MISINFORMATION
Examples of use
Reputation protection: detection and management of disinformation campaigns targeting the company.
Strategic intelligence: analysing the authenticity of market information for decision-making purposes.
Employee training: raising awareness of how to detect misinformation in the workplace.
AI AGENTICS
Agentic AI refers to AI systems capable of acting autonomously to achieve specific objectives, making decisions and interacting with their environment.
AI AGENTICS
Examples of use
Process automation: AI agents managing complex workflows autonomously
Personalised assistance: virtual agents providing tailored support for employees and customers
Real-time optimisation: continuous adjustment of operational strategies in response to changes in the environment.
AI-ENHANCED SOFTWARE ENGINEERING
AI Augmented Software Engineering (AIASE) is the application of artificial intelligence technologies to assist software engineers throughout the software development lifecycle. This includes creating, validating, securing, deploying and maintaining applications.
AI-ENHANCED SOFTWARE ENGINEERING
Examples of use
Optimisation of development processes: automation of code generation to reduce delivery times.
Improved software quality: proactive detection of anomalies thanks to AI.
Inter-team collaboration: use of AI tools to simplify communication between developers and decision-makers.



General objective

On a rigorous, forward-looking, and internationally anchored basis, the primary objective of this inquiry is to identify the digital technologies most likely to reshape managerial work, organizational transformation, and, by extension, the competence profile of business managers. To this end, we adopt a structured evidence-synthesis approach that integrates multiple knowledge sources (industry research, skills/labour-market analytics, standards and regulatory frameworks, and scholarly literature), rather than relying on a single provider. We adopted Gartner as the primary foresight lens because it offers a coherent, widely used framework for comparing emerging technologies by maturity, expected benefit, and years-to-mainstream, enabling transparent, replicable prioritization (Hype Cycle 2024; Priority Matrix). The Adoption Radar 2025 complements this by focusing on near-term applicability (themes and time rings), while AI-Augmented Development (2024) supplies immediate, operational practices for piloting value, together providing a practical bridge from foresight to managerial action, which we then validated via expert elicitation.

Analytical lenses and rationale

We combined three complementary Gartner instruments to structure our technology scan and competence mapping. First, the "Hype Cycle for Emerging Technologies 2024" provided a maturity framework and ex ante impact segmentation, using canonical phase progressions (from Innovation Trigger to Plateau of Productivity), benefit ratings (Transformational/High/Moderate/Low), and years-to-mainstream buckets that support realistic staging of adoption pathways.

Second, the "Emerging Technologies Adoption Radar 2025" supplied an applicability lens, organizing items into four themes (Productivity Boosters; Intuitive Edge; Human–Machine Relations; Foundational Enablers) and time rings, to identify where and how to apply in the near term (e.g., agentic/autonomous AI, machine customers, AR cloud, green software engineering, disinformation security). This radar explicitly complements the Hype Cycle by prioritizing practical entry points. Third, "Top Strategic Technology Trends 2024: AI-Augmented Development" grounded immediate, operational changes in software-enabled transformation (coding assistants, AI-augmented testing, and design-to-code), which we treat as near-term managerial levers with stated adoption assumptions through 2028.

Integration logic

In our method, the Hype Cycle indicates when a technology is likely to mature and its expected benefit band; we positioned items by Hype Cycle phase and years-to-mainstream; at entry to the Plateau of Productivity, approximately 20% of the target audience has adopted the technology; the Adoption Radar indicates where/how to apply now, given organizational context; the AI-Augmented Development trend provides concrete practices managers can deploy immediately to capture value and evidence early outcomes.

Expert elicitation

To avoid mechanical reading of vendor research, we paired these lenses with structured expert elicitation from the research group (topic leads for AI, data/analytics, software delivery, and governance). 2 experts reviewed each candidate technology against a rubric (benefit × feasibility × competence impact) and produced short analytical cards used in workshops; disagreements were resolved by consensus after referencing the relevant Gartner construct (Hype Cycle phase/benefit or Radar theme/ring) and, where applicable, the AI-Augmented Development practice taxonomy.

#	Technology	Gartner source	Theme / Phase (per source)	Benefit (band)	Years to mainstream
1	Generative AI	Hype Cycle 2024	Autonomous AI (theme)	High–Transformational	2–5 / 5–10
2	Autonomous / Agentic AI	Hype Cycle 2024	Autonomous AI (theme)	High–Transformational	5–10
3	Large Action Models	Hype Cycle 2024	Developer Productivity / Autonomous AI	High	5–10
4	AI-Augmented Software Engineering	Top Strategic Tech Trends 2024	Practice domain (coding assistants, AI testing, design-to-code)	High (near-term)	<2 / 2–5
5	Prompt Engineering	Hype Cycle 2024	Developer Productivity (theme)	High	<2 / 2–5
6	AI TRiSM	Hype Cycle 2024	Human-Centric Security & Privacy	High	2–5
7	Disinformation Security	Hype Cycle 2024	Human-Centric Security & Privacy	High	2–5
8	Human-Centric Security & Privacy	Hype Cycle 2024	Human-Centric Security & Privacy	High	2–5
9	Machine Customers	Hype Cycle 2024	Total Experience / Business Model	Transformational	5–10
10	Digital Twin of a Customer (DToC)	Hype Cycle 2024	Total Experience / Digital Twins	High	5–10
11	Digital Twin of the	Hype Cycle 2024	Digital Twins	High	5–10

	Organization (DTO)				
12	Spatial Computing	Hype Cycle 2024	Experience / Interface	High	5–10
13	AR Cloud	Adoption Radar 2025	Intuitive Edge (theme)	High (applicability)	Near- / Mid-term ring
14	Green Software Engineering	Adoption Radar 2025	Foundational Enablers	High (applicability)	Near-term ring
15	Neurosymbolic AI	Adoption Radar 2025	Productivity Boosters	High (applicability)	Mid-term ring
16	Process Mining Platforms	Adoption Radar 2025	Productivity Boosters	High (applicability)	Near- / Mid-term ring
17	Decision Intelligence Platforms	Adoption Radar 2025	Productivity Boosters	High (applicability)	Mid-term ring
18	Polyfunctional / Smart Robots	Adoption Radar 2025	Human–Machine Relations	Moderate–High	Mid-term ring
19	6G	Hype Cycle 2024	Foundational Connectivity	High	>10 / 5–10
20	AI Supercomputing	Hype Cycle 2024	Foundational Enablers	Transformational	2–5 / 5–10
21	Homomorphic Encryption	Hype Cycle 2024	Human-Centric Security & Privacy	Moderate–High	5–10

22	Cloud-Native (next-gen)	Hype Cycle 2024	Developer Productivity / Platform	High	<2 / 2–5
23	Edge GenAI patterns	Adoption Radar 2025	Intuitive Edge	High (applicability)	Near- / Mid-term ring
24	Quantum Computing (enterprise)	Hype Cycle 2024	Foundational Enablers	Transformational (long-term)	>10

Legend & notes

- **Hype Cycle 2024** rows use Gartner's themes (e.g., Autonomous AI, Human-Centric Security & Privacy) and give benefit bands and years-to-mainstream at an indicative level consistent with the Priority Matrix and maturity narrative.
- **Adoption Radar 2025** rows use themes (Productivity Boosters; Intuitive Edge; Human–Machine Relations; Foundational Enablers) and time rings (near/mid/long) to signal where/how to apply now; benefit is expressed as applicability for near-term entry points.
- **AI-Augmented Software Engineering** is taken from Top Strategic Technology Trends 2024: AI-Augmented Development and treated as a near-term practice domain (coding assistants, AI-augmented testing, design-to-code) that managers can pilot immediately.

Gartner notes you used (full titles, IDs, dates).

- *Hype Cycle for Emerging Technologies, 2024* (ID G00812275).
- *Emerging Technologies Adoption Radar, 2025* (ID G00823535).
- *Top Strategic Technology Trends 2024: AI-Augmented Development* (ID G00796461).

Appendix 2. Systematic Literature Review conducted by the University of Pavia

1. Purpose of the research

Technological skills are expected to grow at a faster pace than other skill sets, transforming both the landscape of education and the demands of future employment (Singh, 2025; WEF, 2025). As a result, the integration of digital technologies within Higher Education Institutions (HEIs) is essential, not only for enhancing students' digital competencies but also for directly shaping their professional prospects (Rodrigues et al., 2021). Similarly, HEIs are being called to train their workforce with the skills needed to thrive in the digital-driven economy nowadays (Singh, 2025). Thus, the main objective of this research is to evaluate the use and implementation of future technologies and digital skills within the education sector through a systematic literature review (SLR). This effort aims to support the development of the Targeted Skills Framework (TSF), as part of the main tasks of Work Package one (WP1) for the DIGI-ME project.

2. Research methodology

Following the methodology proposed by Campos-Arsenio (2018) for developing a bibliographic search strategy, various sets of keywords were identified and organized into three conceptual categories: (a) Education, (b) Digital Skills and Technology, and (c) Managerial and Soft Skills. These categories are detailed in the table below.

Table 1. Conceptual categories of identified keywords.

Terms concept 1 **Education**	**Terms concept 2** **Digital skills/ Technology**	**Terms concept 3** **Managerial skills / Soft skills**
Higher education institutions	Digital transformation	Strategic planning
University digital skills	Digital innovation	Decision making in digital environments
Business education	Emerging technologies	Team management
Management education	Digital skills	Digital adaptability
Curriculum innovation	Digital competencies	Problem-solving skills

Technology-enhanced learning	Artificial intelligence	Change management in digital transformation
Future learning	Machine learning	Digital entrepreneurship
Smart learning environments	Blockchain	Critical thinking
Higher Education innovation	Virtual reality	Upskilling
E-learning	Internet of things	Digital leadership
Innovative learning	Digital twins	Communication competencies
Pedagogic innovation	Digital tools	Emotional intelligence

Additionally, a search query was developed to retrieve academic articles:

TS=(("Higher education institutions" OR "University digital skills" OR "Business education" OR "Management education" OR "Curriculum innovation" OR "Technology-enhanced learning" OR "Future learning" OR "Smart learning environments" OR "Higher Education innovation" OR "E-learning" OR "Innovative learning" OR "Pedagogic innovation")

AND ("Digital transformation" OR "Digital innovation" OR "Emerging technologies" OR "Digital skills" OR "Digital competencies" OR "Artificial intelligence" OR "Machine learning" OR Blockchain OR "Virtual reality" OR "Internet of things" OR "Digital twins" OR "Digital tools")

AND ("Strategic planning" OR "Decision making in digital environments" OR "Team management" OR "Digital adaptability" OR "Problem-solving skills" OR "Change management in digital transformation" OR "Digital entrepreneurship" OR "Critical thinking" OR Upskilling OR "Digital leadership" OR "Communication competencies" OR "Emotional intelligence"))

Two databases were selected to conduct this research: Web of Science and Scopus, as they are affiliated with the University of Pavia. The initial search identified 112 articles from Web of Science (WoS) and 484 articles from Scopus. After removing 61 duplicate entries, a combined database of 535 unique articles was created. A study selection process was then carried out by reviewing the full text of the articles. Ultimately, 164 articles were excluded

due to lack of access to the full text (restricted by payment requirements) or because the articles were not available in English. As a result, the final database consisted of 371 articles. Figure 1 illustrates in more detail the flow scheme followed during the analysis.

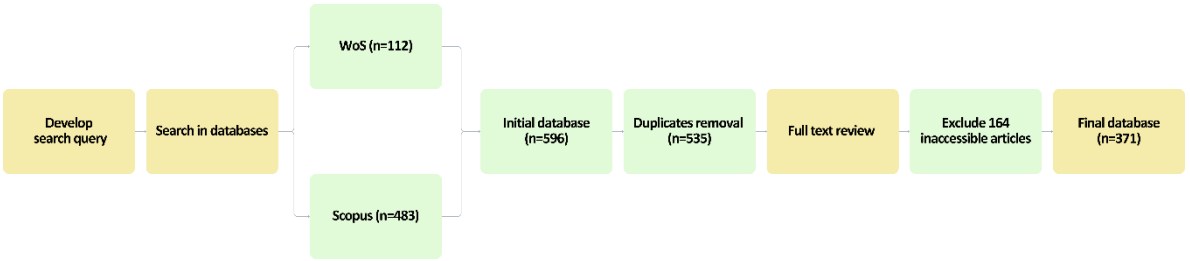


Figure 1. Flow scheme of the study selection

Data analysis

The database included the collection of various types of information, such as bibliographic details (authors' names, publication titles, sources, types of publication, and years of publication), research objectives (main research questions and hypotheses), methodology information (type of methodology, study region, and sample size), and key findings (relevant results, types of digital and managerial skills and competencies identified, and suggested directions for future research). Finally, the compiled data was analyzed by content analysis and descriptive statistics, facilitated using Chat GPT 4,0 plus. Research suggests that LLMs, like Chat GPT, could prove to assist in diverse phases of data analysis (Leas et al., 2024). Similarly, Kuppelwieser et al., 2025 identified some benefits between traditional literature review processes and AI partnerships such as more comprehensive responses to reviews, better organization of revision process and enhanced efficiency addressing feedback. However, recommendations of multiple iterations to determine the reliability of the research as a mitigation measure are recommended (Bijker et al., 2024). To minimize the risk of hallucinations, researchers recommend developing effective prompts by clearly defining the goal, selecting an appropriate format, providing sufficient context, and refining them iteratively (Marvin et al., 2024). Thus, Kuppelwieser et al. (2025) recommend that researchers verify AI generated outputs against original sources, cross-checking interpretations to ensure overall alignment.

Building on these suggestions, this study designed and tested prompts on a representative subsample of at least 20% (n=74). The focus was on verifying citations underpinning the theoretical framework and ensuring consistent engagement with foundational literature, regardless of the extent of AI assistance (Kuppelwieser et al., 2025). Prompts were verified and refined during the pilot test, as illustrated in Table 2 below. Then manually obtained results were analyzed using descriptive statistics and content analysis, then compared with ChatGPT's 4.0 Plus outputs. Descriptive analyses were cross-checked using Excel calculations, while content analyses were double-checked using ATLAS.ti software for word frequency verification. Once alignment was confirmed, the validated prompts were applied to the full database.

Table 2. Prompts used for data analysis

Topic	Prompt	Prompt refinements (if any)
Year of publication	Perform a descriptive statistical analysis of column H "Year" of the provided dataset, providing the percentage that each year represents out of the total without further interpretation of the database. Please provide results in a list.	1
Journals	Perform a descriptive analysis of column L "Journal" of the dataset, specifically calculating the percentage of the categories in this specific column, without further interpretation	0
Region of study	Perform a descriptive analysis of column S "Region" of this dataset, specifically calculating the percentage of each category relative to the total, without further interpretation.	0
Methodology	Perform a descriptive analysis of column O "Methodology" of this dataset, specifically calculating the percentage of each category, without further interpretation.	0

Research	Provide a frequency count on the most concurrent words on column N "research" of the dataset provided. Do not add interpretations beyond the dataset.	1
Digital competencies	Provide a frequency count on the most concurrent words on column V "digital competencies" of the dataset provided. Do not add interpretations beyond the dataset.	0
Managerial competencies	Provide a frequency count on the most concurrent words on column W "managerial competencies" of the dataset provided. Do not add interpretations beyond the dataset.	0
Use of technologies	Provide a frequency count on the most concurrent words on column X "technologies" of the dataset provided. Do not add interpretations beyond the dataset.	0
Future research	Provide a frequency count on the most concurrent words on column Y "future research" of the dataset provided. Do not add interpretations beyond the dataset.	0

3. Findings

Year of publications

Most of the analyzed literature was published in recent years, since almost 66% of it corresponds to the years 2024-2022. *Figure 2* showcases the publication years and corresponding percentages.

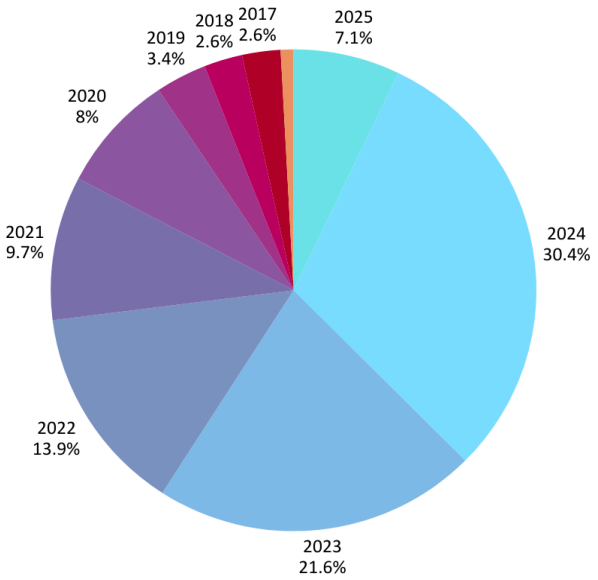


Figure 2. Overview of year of publications

Most of the articles were published in the proceedings of international conferences, while around 30% of them were published in academic journals. Some of the journals with higher representation are the following (with no more than two occurrences):

- The International Journal of Advanced Computer Science and Applications
- Journal of Research in Innovative Teaching and Learning
- International Journal of Management Education
- International Journal of Emerging Technologies in Learning
- International Journal of Information and Education Technology

Methodologic approaches

Most of the research conducted employed a qualitative approach leading with almost 47%, while the quantitative approach had around 38% and mixed-methods approach represented almost 16% of the reviewed literature, as illustrated in Figure 3 below. More specifically for the qualitative research conducted, the main approaches used were case studies (e.g. single study, insider case), thematic analysis, scoping of literature structure or literature review, and use of interviews and grey literature. For quantitative analysis most, literature was characterized by quasi-experimental designs, statistical modelling (e.g. structural equation modelling, regression analysis), topic modelling, and numerical data analysis techniques highlighting the need to answer research objectives and hypothesis testing. Finally, mixed method approaches were implemented which led to common practices of interviews, surveys, systematic literature reviews, and statistical analysis.

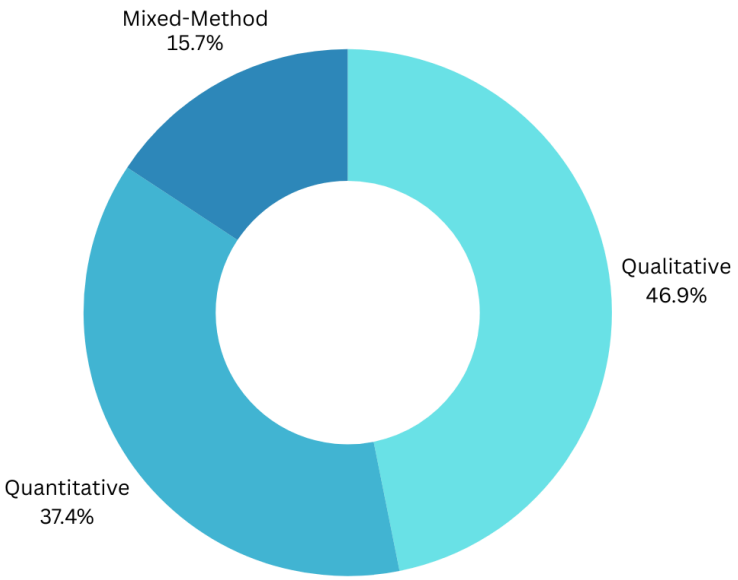


Figure 3. Representation of chosen methodological approaches

Regions of studies

In general, studies with European contexts predominated with almost 31%, followed by Asian countries with 29,7% reflecting a strong contribution from East and Southeast Asian countries mainly. A global focus with 10,7% was also predominant in the analyzed literature, followed by the North American region with 10,4%. Figure 4 illustrates the regions in a more detailed manner.

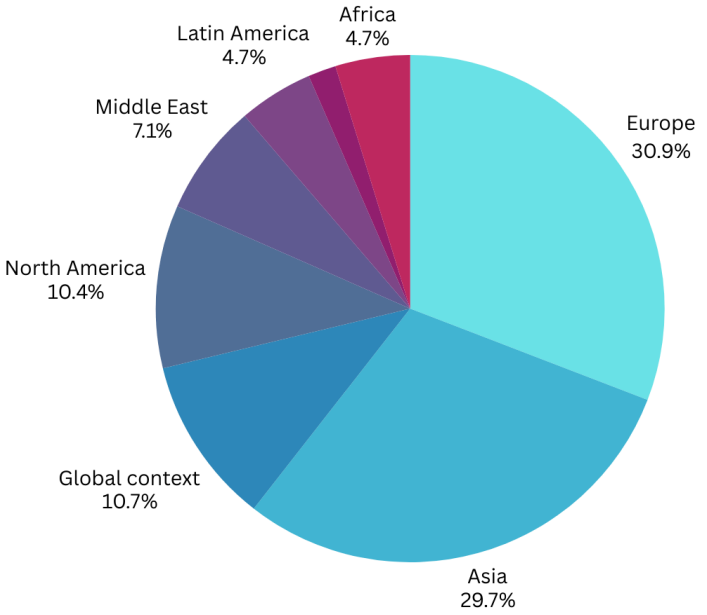


Figure 4. Breakdown of research conducted by regions

Diving into the European context, findings suggest that most research was conducted in Germany (13), Spain (13) and Portugal (11).

Research orientation analysis

Research questions were categorized on recurring themes to better understand the pathways of the research conducted and further objectives. Five main topics were determined. Topic one is **digital media and social use**, which has a strong emphasis on words like students, digital, medial, and study, centering mainly around how digitalization is used in learning environments. The second topic is **AI & online learning development,** with prominent terms being: learning, students, development, AI, education, and online; the focus was mainly related to the development and integration of online and AI learning tools. The third topic is **virtual and critical thinking**, which includes words like learning, education, students, thinking, virtual and critical thinking, indicating a pedagogical approach and focusing mainly on cognitive skills. The fourth topic is regarding **skills and higher education readiness for technological application** which includes words like skills, higher education and artificial intelligence, reflecting themes of academic and professional preparation. Finally, the last and fifth topic concerns **AI-based learning frameworks**, which counts for

learning, digital, education, students and artificial intelligence, including a synthesis of digital infrastructures and pedagogical design.

Together, these five topics provide an idea of the most followed paths of research conducted according to the dataset, as illustrated in Figure 5.

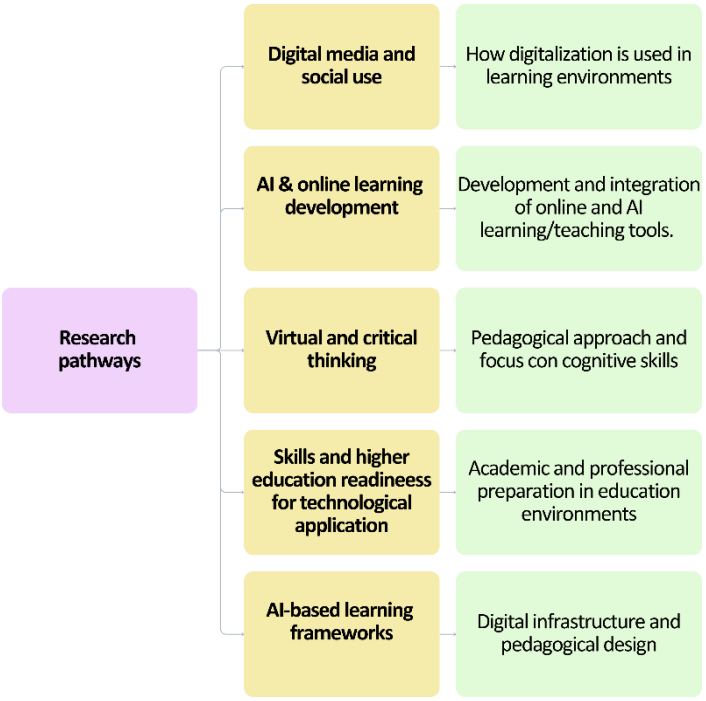


Figure 5. Overview of the five topics of research orientation

Digital competencies

A content analysis of digital skills and competencies was developed to understand the top phrases in this specific regard. The most common phrases for digital skills and competencies were mainly regarding digital literacy, digital use, digital communication, and AI literacy. More details are showcased in figure 6 below:

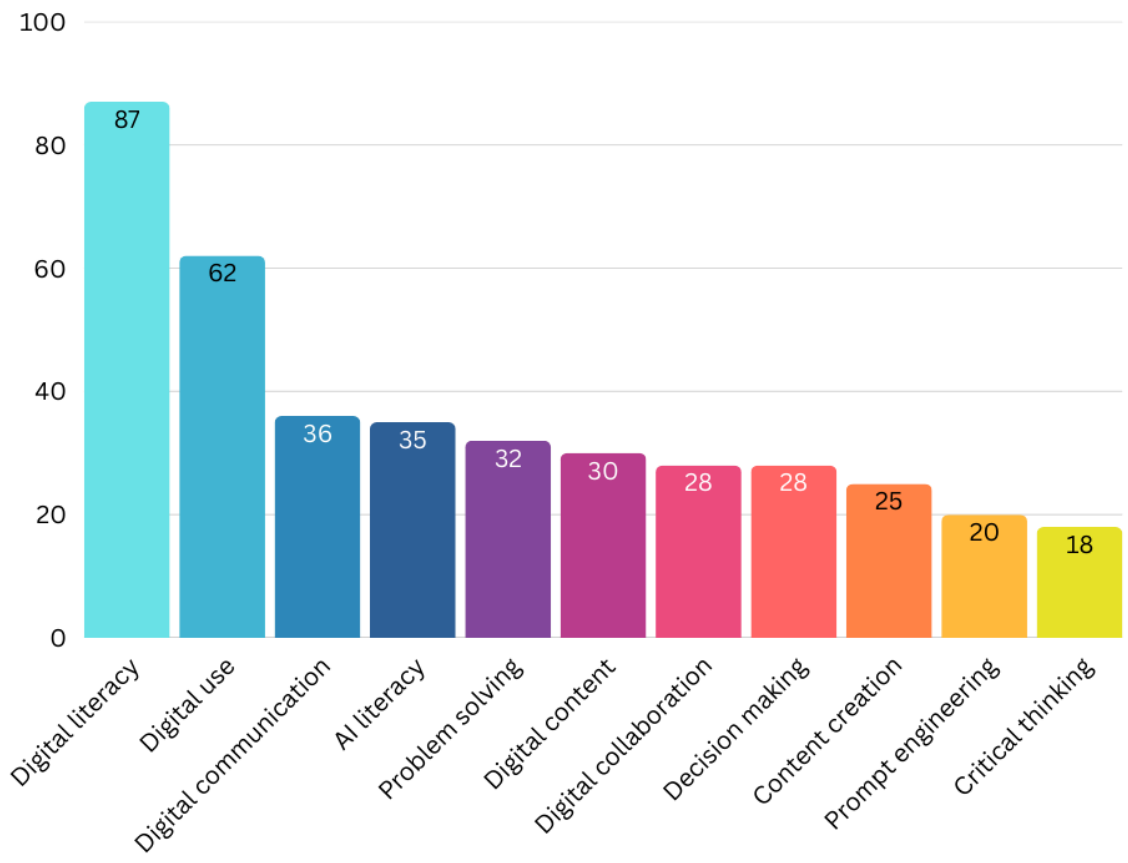


Figure 6. Most mentioned digital competencies in reviewed literature

Managerial competencies

Repeating the previous data analysis approach, a content analysis was conducted to understand the most analyzed managerial competencies and their relationship with digital innovation and future education. The most common phrases in the studied literature were problem solving skills, critical thinking, and decision-making. Figure 7 illustrates the most common managerial competencies analyzed:

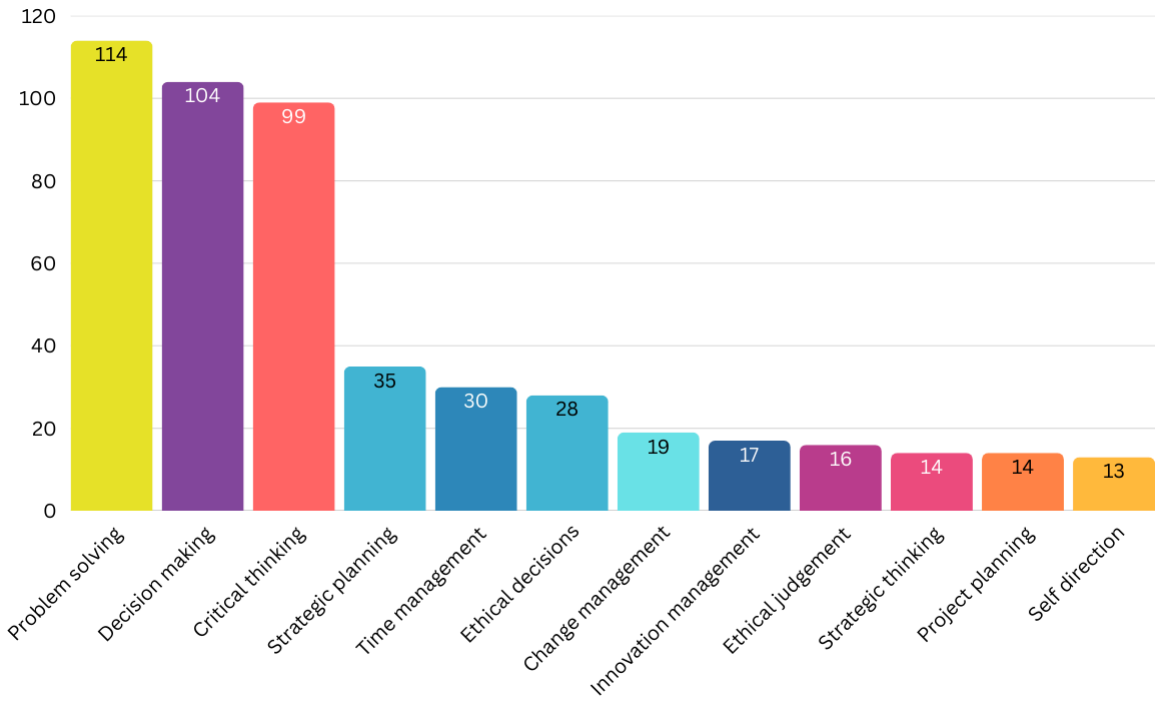


Figure 7. Most mentioned managerial competencies in reviewed literature

Technology use

The use of technology was also analyzed to understand what kind of technology is being studied in the literature. The most frequent technologies researched according to our dataset are virtual reality (105 occurrences), artificial intelligence (AI) (with 75 occurrences), digital learning platforms (59 occurrences), augmented reality (AR) (with 44 occurrences), machine learning (with 38 occurrences), and generative AI (with 20 occurrences). Figure 8 maps out in a radar chart these concurrent technologies.

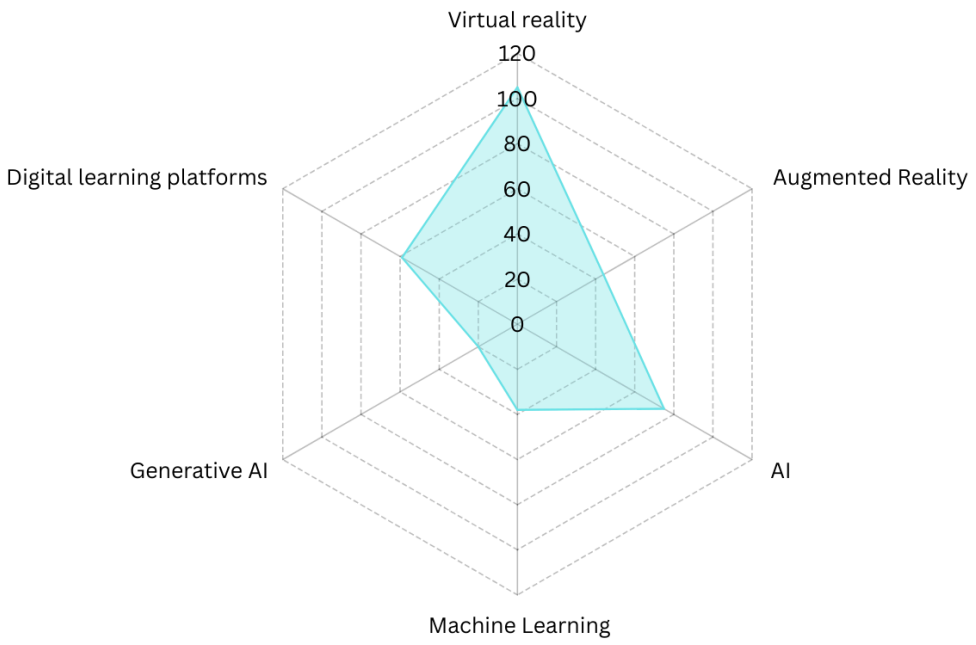


Figure 8. Most mentioned technologies in literature

Focus on future research

A thematic analysis of the recommendations yielded seven key areas for future research. First, scholars emphasize the importance of international and cross-cultural comparisons, highlighting the need to understand how technological applications and user interactions vary across regulatory, cultural, and national contexts. This is particularly relevant given the differing legal and ethical frameworks that shape AI deployment around the world. There is also a strong call to enhance real-time analysis and decision-making through advanced machine learning and AI. This includes exploring adaptive algorithms capable of evolving in response to user behavior and dynamic environmental conditions. Moreover, the theme of human-AI collaboration emerged as a significant area for exploration since future work should examine how tasks are coordinated between humans and machines, the role of trust in algorithmic partners, and how AI systems can be optimized for effective teamwork. Also, the ethical dimension of AI development is seen as crucial. Researchers remark on the importance of transparency, fairness, and accountability, calling for systems that are explainable, free from bias, and aligned with societal values and legal standards. An

interdisciplinary approach is encouraged to bridge the gaps between fields since integration of technology is necessary to address multidisciplinary challenges. Finally, there is an emphasis on user-centered design, expressing the need to involve end-users in the development process and to incorporate their feedback. This ensures that AI systems remain relevant, usable, and aligned with user needs.

4. Discussion and conclusions

Digital transformation has increasingly become a strategic priority for HEIs in the second decade of the 21st century (Benavides, 2020), a shift that has been significantly accelerated by the disruptions caused by the COVID-19 pandemic (Monteiro & Leite, 2021). Within this context, the integration of future technologies and digital skills into HEIs has emerged as a relatively new concept that is gaining significant momentum among academic institutions and policymakers. This growing interest reflects a shared understanding of the urgent need to align educational practices with the demands of a fast-evolving digital and complex global environment. The findings of this study, highlight that most of the research on this topic has been published between 2022 and 2024, confirming the novelty of this shift and reflecting the rapidly increasing academic attention toward the integration of future technologies and digital skills in higher education.

Moreover, findings also highlighted that a considerable number of studies relied on a single research method, either qualitative or quantitative. While such approaches provide valuable insights, the adoption of mixed-method designs (Somers et al., 2024; Jayawickrama et al., 2020), may allow for more comprehensive results about digital competence in higher education (Zhao et al., 2021).

The digital competencies identified in this research primarily centered on AI literacy, digital usage, and digital communication, aligning with previous reports which emphasized that technological literacy is a critical and increasingly used skill (WEF, 2025). Moreover, managerial competencies were mostly related to problem solving skills, decision-making, and critical thinking, as suggested by previous research which centered critical thinking as an increasingly important skill for business studies and education (Calma & Davies, 2021). This research found an overlap between some relevant digital and managerial competencies, establishing a connection between them. Being digital competent was defined as -using digital technologies in a critical, collaborative and creative way (Carretero et al., 2017). Adding to this idea, along with technological skills, soft skills such as creative thinking are also rising in importance for lifelong learning and educational purposes (Singh, 2025; WEF, 2025).

Finally, seven key areas were identified for future lines of investigation including the need for international and cross-cultural comparisons, enhanced real-time decision-making through advanced AI, and deeper exploration of human-AI collaboration. Ethical concerns such as transparency, fairness, and accountability were also mentioned by diverse researchers, as special focus on literature relies on business ethics and moral reasoning (Calma & Davies, 2021). The importance of interdisciplinary research pathways was also identified since comparison could help understanding which and how technological skills need to be further merged into diverse areas (Rodrigues et al., 2021). Lastly, a strong focus is placed on user-centered design to ensure AI systems are practical, relevant, and aligned with the user's needs. Similarly, researchers suggest that personalised learning environments are increasing in demand according to the individual learner profile and preferences (Lacave et al., 2018) promoting the importance of learning analytics to reveal how learners engage with diverse teaching materials according to their profiles (Edelsbrunner et al., 2022; Ifenthaler & Yau, 2020).

To conclude, this investigation offers an overview of the most studied competencies in both digital and managerial domains. The rapid evolution of technology continues to reshape this landscape, presenting both significant opportunities and ongoing challenges (Singh, 2025). A key challenge lies in the constant need to update and integrate these competencies into academic curricula to ensure they remain relevant and aligned with the demands of an increasingly dynamic and competitive environment.

References

Benavides, L. M. C., Tamayo Arias, J. A., Arango Serna, M. D., Branch Bedoya, J. W., & Burgos, D. (2020). Digital transformation in higher education institutions: A systematic literature review. *Sensors*, *20*(11), 3291. https://doi.org/10.3390/s20113291

Bijker, R., Merkouris, S. S., Dowling, N. A., & Rodda, S. N. (2024). ChatGPT for automated qualitative research: Content analysis. *Journal of Medical Internet Research*, *26*, e59050. https://doi.org/10.2196/59050

Calma, A., & Davies, M. (2020). Critical thinking in business education: Current outlook and future prospects. *Studies in Higher Education*, *46*(11), 2279–2295. https://doi.org/10.1080/03075079.2020.1716324

Campos-Asensio, C. (2018). How to develop a bibliographic search strategy. *Enfermería Intensiva (English Ed.)*, *29*(4), 182–186. https://doi.org/10.1016/j.enfie.2018.09.001

Carretero, S.; Vuorikari, R.; Punie, Y. *DigComp 2.1: The Digital Competence Framework for Citizens with Eight Proficiency Levels and Examples of Use*; Publications Office of the European Union: Luxembourg, 2017.

Edelsbrunner, S., Steiner, K., Schön, S., Ebner, M., & Leitner, P. (2022). Promoting digital skills for austrian employees through a MOOC: Results and lessons learned from design and implementation. *Education Sciences*, *12*(2), 89. https://doi.org/10.3390/educsci12020089

Ifenthaler, D., & Yau, J. Y.-K. (2020). Utilising learning analytics to support study success in higher education: A systematic review. *Educational Technology Research and Development*, *68*(4), 1961–1990. https://doi.org/10.1007/s11423-020-09788-z

Jayawickrama, T., Abdelaal, S., & Abadia, R. (2020). Using online learning environments to address digital literacy competencies of construction management graduates. In *International Conference on Computers in Education* (pp. 670-679).

Kuppelwieser, V., Cobelli, N., Cassia, F., & Rosenbaum, M. S. (2025). AI-enhanced literature reviews: Liberating scholars for impact in service marketing. *Journal of Services Marketing*. https://doi.org/10.1108/jsm-05-2025-0330

Lacave, C., Molina, A. I., & Cruz-Lemus, J. A. (2018). Learning Analytics to identify dropout factors of Computer Science studies through Bayesian networks. *Behaviour & Information Technology*, *37*(10–11), 993–1007. https://doi.org/10.1080/0144929x.2018.1485053

Leas, E. C., Ayers, J. W., Desai, N., Dredze, M., Hogarth, M., & Smith, D. M. (2024). Using large language models to support content analysis: A case study of chatgpt for adverse event detection. *Journal of Medical Internet Research*, *26*, e52499. https://doi.org/10.2196/52499

Marvin, G., Hellen, N., Jjingo, D., & Nakatumba-Nabende, J. (2024). Prompt engineering in large language models. In *Algorithms for Intelligent Systems* (pp. 387–402). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-7962-2_30

Monteiro, A., & Leite, C. (2021). Digital literacies in higher education: Skills, uses, opportunities and obstacles to digital transformation. *Revista de Educación a Distancia (RED)*, *21*(65).

Rodrigues, A. L., Cerdeira, L., Machado-Taylor, M. de L., & Alves, H. (2021). Technological skills in higher education—different needs and different uses. *Education Sciences*, *11*(7), 326. https://doi.org/10.3390/educsci11070326

Singh, A. (2025). *Future of jobs prospect through artificial intelligence by 2030*. Elsevier BV. https://doi.org/10.2139/ssrn.5213331

Somers, C., Feenan, D., Fitzgerald, D., Henriques, R., Martignoni, M., Parletta, D. A., & González–Vélez, H. (2024, July). Systematic needs analysis of advanced digital skills for postgraduate computing education: The DIGITAL4Business case. In International Conference on Artificial Intelligence in Education (pp. 179-191). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-64315-6_14

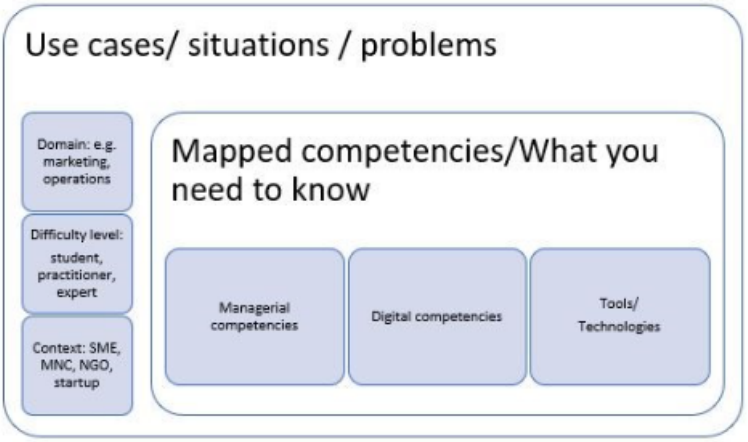
World Economic Forum. (2025) *The Future of Jobs Report 2025.* Retrieved from: https://www.weforum.org/publications/the-future-of-jobs-report-2025/in-full/3-skills-outlook/#3-2-drivers-of-skill-disruption

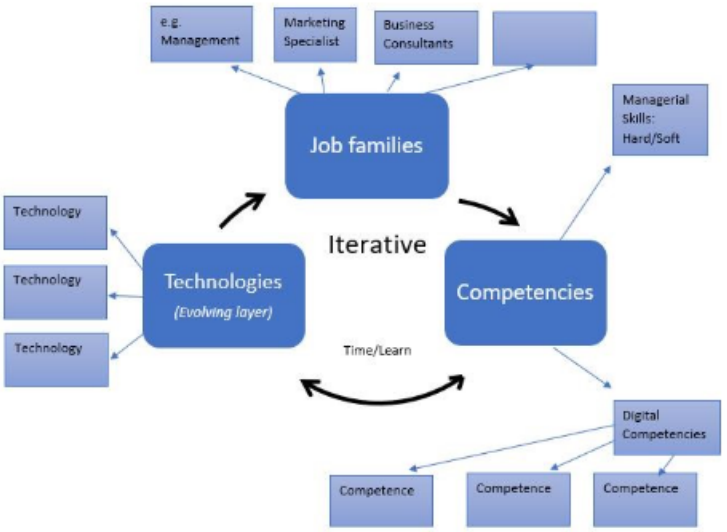
Zhao, Y., Llorente, A. M. P., & Gómez, M. C. S. (2021). Digital competence in higher education research: A systematic literature review. *Computers & education*, *168*, 104212. https://doi.org/10.1016/j.compedu.2021.104212

Appendix 3. Workshop Questions to Determine the Key Components of the Targeted Skills Framework & Summary of the Key Answers

Theme 1. Levels of Analysis	
What levels should our framework address?	**1. Job Families/Profiles**: The top level should categorize broad professional domains (marketing, HR, operations, etc.) **2. Roles/Specializations**: Specific positions within job families (e.g., HR Manager, Digital Marketing Specialist) **3. Competency Domains**: Categories of competencies (technical, managerial, transversal) that span across multiple roles **4. Specific Digital Skills**: Concrete, implementable skills that contribute to competencies **5. Proficiency Levels**: Basic, intermediate, and advanced classifications for each skill **6. Technology Connections**: Explicit links between skills and relevant technologies

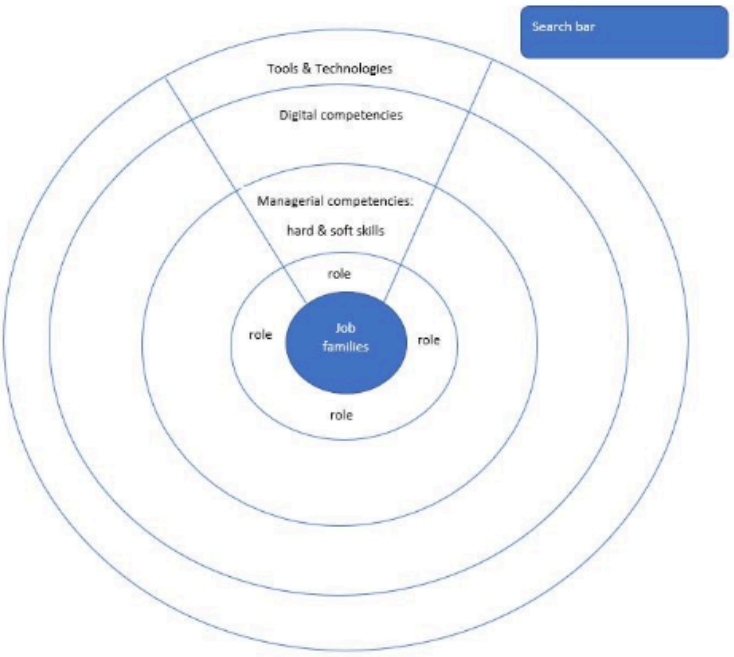
	7. Practical Applications: Case studies and real-world implementation scenarios (level of analysis to be considered for the future iterations of TSF)
What should be the depth for each level?	It was agreed that each HEI would determine the appropriate level of detail for Job Families, Roles & Specializations, Managerial Competencies, and Technology Connections. However, the digital competencies, skills, and proficiency levels are shared across all partner institutions.
Theme 2. Grouping Logic	
What should be the main logic for grouping competencies and skills?	1. **Technology-impact logic**: grouping competencies based on how they are transformed by evolving technologies 2. **Use case specific logic**: organizing competencies by reviewing different situations/problems/use cases and identifying what competencies and skills are required to solve these situations (e.g., deep knowledge about a particular tool and knowing how to apply this tool in different industries to solve different problems 3. **Role-based logic**: connecting competencies to specific job requirements
Do we need fixed categories (e.g., technical, managerial, creative) or flexible groupings that evolve with trends?	**Fixed Categories**: Core competency (Digital, Managerial) – (the components of these competencies are likely to change) **Flexible/Evolving Categories**: Specific technologies and tools (AI applications, emerging platforms); Implementation techniques for digital skills; Industry-specific applications of digital competencies
Theme 3. Specificity & Semantic Quality of Skills	
How specific should digital skills be described?	The description of the digital skills is aligned with DigComp framework
What level of semantic richness is useful for our users?	**High-Level Labels**: Simple, durable terms for major competence areas **Detailed Descriptors**: Richer descriptions of specific competencies **Implementation Examples**: Concrete examples that can be updated frequently **Assessment Criteria**: Specific indicators for determining proficiency
Theme 4. Utility for Users	
Who will use this framework (educators, students, companies, lifelong learners)?	The framework will serve multiple stakeholders: 1. **For Educators**: High semantic richness - detailed skill decomposition, learning progression

	indicators, pedagogical implementation notes, and assessment criteria. 2. **Students**: For career planning, skill development pathways, and self-assessment 3. **Lifelong Learners**: For continuous professional development 4. **Employers**: For recruitment, employee development, and organizational skill mapping
What level of granularity is meaningful for each user group? (e.g., should students see ”AI tools” while educators see ”model training parameters?”)	1. **For Educators**: High semantic richness - detailed skill decomposition, learning progression indicators, pedagogical implementation notes, and assessment criteria. 2. **For Students**: Moderate semantic richness - clear skill descriptions, practical applications, career relevance indicators, and development pathways. 3. **For Employers**: Simplified but precise terminology - workplace performance indicators, measurable skill verification metrics, and clear alignment with organizational needs.
Theme 5. Structure of the Framework	
5.1. What visual structure would best support the framework’s usability across audiences? (e.g., hierarchical tables, matrices, rhizomatic maps, multiple-axis models)	**Structure 1**: This model starts with real-world business problems, situations or challenges, and maps backward to the required competencies and tools.  **Structure 2**: This structure focuses on the dynamic interaction between three key elements: job families, technologies, and competencies.



Structure 3: This structure organizes digital competencies in a hierarchical manner while accounting for their evolution over time.

Structure 4: This structure starts with a job profile and then navigate into competencies, tools. It also suggests an add-on search bar to either visualize skills that "light up" based on selected role or see how technologies like AI manifest in different jobs

Search bar
Tools & Technologies
Digital competencies
Managerial competencies:
hard & soft skills
role
role
Job families
role
role

Appendix 4. Current Job Families and Current Specializations per HEI

University of Vaasa	
Master's Program in Strategic Business Development	
Job Family	**Specializations**
Strategic & Business Development	Strategy Consultant, Business Developer
Sustainability & CSR	Sustainability Manager, ESG Analyst, CSR Consultant
Project & Network Management	Project Manager, Operations Lead
Management Consulting	Strategy/Management/ESG Consultant
Master's Program in International Business	
Job Family	**Specializations**
Global Strategy & Business Development	Global Business Strategist, Strategy Consultant, International Business Developer
International Marketing & Sales	Global Marketing Manager, International Brand Strategist, Business Developer
Entrepreneurship & Innovation	International Entrepreneur
Sustainability & CSR	Sustainability Manager, ESG Analyst, CSR Consultant
Cross-Cultural Management & HRM	Global HR Manager, International Talent Manager, Leadership Development Specialist
Business Research & Analysis	Business Analyst, Market Researcher
Project & Network Management	Project Manager, Operations Lead
Management Consulting	Strategy/Management/ESG Consultant
University of Pavia	
Master's Program in International Business and Entrepreneurship	
Job Family	**Specializations**
Entrepreneurship & Business Consulting	Entrepreneur, Innovation Manager, Product Manager, Project Manager, Marketing Manager, Business Consultant
International Business	Export Manager, Global Manager, Marketing Manager (foreign branches), Scenario/Trend Analyst, Internationalization Consultant
Digital Transformation & Data Science	Digital Transformation Manager, IS Manager, Data Scientist/Analyst, Functional Analyst, AI Designer/Trainer, Digital/Social Media Marketing Specialist
Sustainability Management	Chief Sustainability Officer, ESG Analyst, Head of Non-Financial Reporting, Sustainability Manager, Sustainability Consultant, Sustainable/Circular Entrepreneur, Sustainable Supply Chain Manager, Sustainable Analyst, ESG Specialist
Grenoble School of Management	
Master's Program in Managing with Data & Artificial Intelligence (offer for 2025-2026)	
Job Family	**Specializations**

Innovation	Program manager, business methods engineer, consultant, business analyst/developer, project manager, analyst, digital marketing specialist, international sales manager, R&D strategist, CEO, senior innovation advisor, production and technical director, technology consultant, marketing offer manager, inventory associate, business development analyst, director of markets and partnerships, data science consultant
Business Development and Marketing	Business development manager, marketing/business development representative/manager, key account manager, projects manager, (strategy) consultant, digital marketing specialist/analyst, sales engineer, sales and marketing manager, product manager, brand manager, digital & ecommerce, campaign manager, marketing and communication officer, social media specialist, traffic manager, media manager, CRM and customer relations manager, data specialist junior, customer success manager, customer satisfaction project manager.
General management / strategy / finance / purchasing	Financial analyst business development analyst / operations analyst, analyst director, international project manager, product marketing manager, management consultant, international consulting engineer, director of operations, buyer, supply chain manager / specialist, purchasing manager finance and operations manager, institutional hedge fund solutions analyst, treasury analyst, financial auditor, data analyst, technology strategy consultant, account development executive customers' officer, manager real estate analyst.

Appendix 5. Managerial competencies per HEI

University of Vaasa
Master's Programme in Strategic Business Development
ILO1: Strategic business development process - Ability to plan and implement comprehensive business development processes in various contexts by using frameworks and tools of strategic management
ILO2: Sustainability and ethics in strategic management - Ability to recognize the key aspects of strategic management vital in promoting sustainability and ethical management and conduct strategic business planning accordingly
ILO3: Managerial work in international contexts - Ability to manage business development processes in multicultural teams, international projects, international, organizations, international business networks and global markets
ILO4: Problem solving and decision-making skills - Ability to creatively solve problems concerning economic, business and managerial issues in various contexts
ILO5: Critical and analytical thinking - Ability to search and use information, approach issues from various angles, differentiate between important and non-important issues, and use consistent logic in one's own argumentation
ILO6: Communication skills - Ability to express themselves orally and in written form in working life situations of one's own field. Students also should possess good abilities for giving presentations in public.
ILO7: Interpersonal skills and teamwork skills - Ability to work with different people and understand the principles behind working effectively in teams and be able to function as responsible members of a team
ILO8: Digital knowledge and skills - Ability to identify new trends of organizational digitalization in terms of digitalized processes, technologies and types of applications relevant for implementing digital transformation in strategic management. Digital skills in using certain basic applications
Master's Programme in International Business
ILO1: Knowledge and understanding 1_Global Strategies in a digitized world - Demonstrate an advanced knowledge of the key concepts and theories in globalization strategies and how to develop global digital business strategies
ILO2: Knowledge and understanding 2_Global marketing and entrepreneurship - Demonstrate an advanced knowledge of the key concepts and theories in global marketing strategies and entrepreneurial growth in an uncertain and complex global environment
ILO3: Knowledge and understanding 3_ Leading people in global business environment - Demonstrate an advanced knowledge of the key concepts and theories in global human resource management and leadership, how to create plans to support the employees' competences and performance and how to develop global leadership
ILO4: Knowledge and understanding 4_Sustainability and ethics in global business - Demonstrate an advanced knowledge of the key concepts and theories on sustainability and ethics and the challenges and

opportunities which are related to the integration of economic, social and environmental dimensions of sustainable development in global business
ILO5: Intellectual skills 1_Critical thinking, analysis and synthesis - Capability to identify assumptions, evaluate statements in terms of evidence, to detect false logic or reasoning, to identify implicit values, to define terms adequately and to generalize appropriately
ILO6: Intellectual skills 2_Decision making and problem solving - Capability to identify business problems and opportunities in a volatile, uncertain, complex and ambiguous global environment and solve them for sustainable global business using appropriate methods such as research, co-operation and networking
ILO7: Intellectual skills 3_Busines research and analysis - Capability to gather primary and secondary data, analyse, evaluate and apply research findings into practice and / or decision making in global context
ILO8: Transferable skills 1_Cross-Cultural communication and negotiation skills - Communicate and negotiate effectively in oral and written form both in physical and digital environment in cross-cultural setting
ILO9: Transferable skills 2_Collaboration in diverse teams - Work effectively in cross-cultural teams both as a team member and as a leader respecting the talents and beliefs of others regardless of their background
ILO10: Transferable skills 3_ Self management - Ability to set priorities and to allocate time efficiently in order to meet deadlines, take initiatives, constantly developing practices and internalising routines for maximising one's ability to deal with the uncertainty of an ever-changing environment and plan personal and career development

University of Pavia		
Managerial competencies in accordance to the tracks offered by the MIBE programme: International Management, Digital Management and Sustainable Management		
Job Family	**Specializations/Typical Roles**	**Managerial Competencies (ILOs)**
Entrepreneurship & Business Consulting	Entrepreneur, Innovation Manager, Product Manager, Project Manager, Marketing Manager, Business Consultant	- Strategic goal-setting - Market opportunity analysis and vision creation - Cross-functional coordination - Team leadership and collaboration - Scenario analysis and risk awareness - Resource mobilization - Soft skills: leadership, creative thinking, public speaking
International Business	Export Manager, Global Manager, Marketing Manager (foreign branches), Scenario/Trend Analyst, Internationalization Consultant	- International strategy formulation - Trend and market context analysis (economic, legal, socio-cultural) - Entry strategy assessment - Cross-cultural marketing and negotiation - Scenario planning

		- Soft skills: negotiation, leadership, public speaking
Digital Transformation & Data Science	Digital Transformation Manager, IS Manager, Data Scientist/Analyst, Functional Analyst, AI Designer/Trainer, Digital/Social Media Marketing Specialist	- Digital and data strategy definition - Understanding digital economy dynamics - Leading digital change processes - Data science and management - Digital marketing, lean management, experiment design -Knowledge of data tools (e.g., R, Python)
Sustainability Management	Chief Sustainability Officer, ESG Analyst, Head of Non-Financial Reporting, Sustainability Manager, Sustainability Consultant, Sustainable/Circular Entrepreneur, Sustainable Supply Chain Manager, Sustainable Analyst, ESG Specialist	- Strategic vision on sustainable business practices - Integration of ESG criteria across value chain - Non-financial reporting and sustainability assessment - Circular economy and responsible innovation - Stakeholder engagement and impact evaluation - Leadership in sustainability-oriented transformation - Soft skills: ethical decision-making, communication, team collaboration

Grenoble School of Management – Master in Strategic Management of International Business	
Competency block 1: Drawing up or co-constructing a national and international strategic vision for the company and its application to a business activity	Monitor developments in the company's ecosystem and anticipate possible changes and innovations in order to guide strategic decisions
	Steer or co-steer the development of an international strategic vision by defining objectives and paying attention to the meaning give to them, taking into account the economic and social impact of decisions
	Define the policy for mobilising resources and networks to implement the strategy within the scope of the Division in question
	Analyse the cash flow statement to assess the company's financial health
	Analyse the main ratios (profitability, liquidity, working capital and working capital requirements, debt, return on investments, etc.) to inform strategic decision-making
	Question the value creation model and the types of performance observed and used to make decisions,

	particularly in the light of stakeholders, CSR issues and ethical principles
Competency block 2: Managing extended teams in an international and intercultural context using responsible leadership practices	Develop self-knowledge (modes of action, communication, etc.) by regularly engaging in reflective practices concerning professional and managerial actions and by evaluating skills in the light of changes in the job, the organization and society, so as to define areas for improvement
	Adapting written and spoken communication to an intercultural audience and to different professional contexts (leading meetings, interviews, arguments in interpersonal or group situations) in order to ensure that the message is conveyed and that the desired quality of the relationship is maintained
	Manage the organization and lead teams, ensuring the inclusion of different staff profiles, in an international and intercultural context, around the strategic priorities and their implementation
	Use your responsible leadership skills to involve employees or teams in transforming the organization, while taking account of the associated environmental and social issues
	Plan and manage a multidisciplinary and intercultural project using appropriate project management methods and tools
	Advising and negotiating with teams and business partners in a cross-cultural context, while observing ethical and professional principles
Competency block 3: Define the operational priorities for deploying the international strategy within a give business area	Investigate more specifically the characteristics of the external environment relevant to the scope of activity under consideration
	Identify the rules and standards specific to the activity and business lines within the scope under consideration in order to define the vigilance measures and the rule for their implementation, where necessary, a re-examination of the existing organization and processes, and the updating of the necessary skills
	Implement the policy, processes and practices needed to translate guidelines and priorities into action planes
Competency block 4: Managing investment choices, operational performance and the risks of international activities with a view to continuous improvement	Evaluate investment opportunities in relation to the planned strategy
	To steer financial and non-financial indicators in order to guide operational activities specific to the business lines and activities concerned, enabling the effects and results of the action plans undertaking to be assessed, paying close attention to the customer journey and the customer experience

	Determine the priorities and methods for managing risks on the basis of their mapping and qualifications, in order to reduce the exposure of the activity and the company to them
Competency Block 5: Manage innovation processes within a given business area	Organize a monitoring system specific to the scope of activity in order to identify societal as well as technological trends that could be the source of innovations concerning the practices, processes and businesses within the scope of responsibility
	Organize the identification and management of discussions on digital uses and the impact of their development on the relevant area(s) of the business sector's activities and processes
	Promote and manage the innovation processes within its scope of activity, in line with the company's innovation policy
Competency block 6: Conducting and defending in-depth studies of a strategic management topic based on scientific reasoning and highly specialized knowledge	Identify , select and analyse critically various sources of highly specialized knowledge in order to document a subject and synthesise this data with a view to using it
	Define and investigate a strategic management problem using a scientific approach, resources, methodologies and reasoning in order to produce a written document containing a structured, in-depth and reliable analysis leading to original proposals for the activity, company or sector
	Defend, in writing, the analysis proposed and the approach adopted before different audiences in order to convince them of the conclusions and recommendations formulated in French or is a foreign language

Appendix 6. Findings from the workshops per HEI

University of Vaasa

The results from the workshops conducted by the University of Vaasa are summarised in the table below.

Digital competencies and skills extracted from DETI workshops' results		
Digital Competencies (aligned with DigComp)	**Digital Skills from DETI**	**Digital Skills as presented in DigComp**
1. Information and Data Literacy	Data literacy	1.2. Evaluating data, information and digital content
	Digital Tools Proficiency	1.1. Browsing, searching and filtering data, information and digital content
	Critical Evaluation of Digital Sources	1.2. Evaluating data, information and digital content
3. Digital Content Creation	Rapid Prototyping and Iteration	3.4. Programming
	Service Design and Agile Methods	3.1. Developing digital content
4. Safety	Cybersecurity Awareness	4.1. Protecting devices
5. Problem Solving	Digital Tools Proficiency, Decision-Making with Incomplete Data	5.2. Identifying needs and technological responses
	Service Design and Agile Methods	5.3. Creatively using digital technology
	Feedback-Driven Development and Adaptability	5.3. Creatively using digital technology
	Customer-Centric Design and Service Thinking	5.2. Identifying needs and technological responses
	Change Agency: Leading with Empathy and Vision	5.1. Solving technical problems & 5.2. Identifying needs and technological responses
New Digital Competencies (as emerged from DETI Workshops)	**Digital Skills from DETI**	**Suggestion for presenting a skill in TSF**
****7. Digital Self-Development and Reflective Practice***	Curiosity and Exploration of New Tools	*7.1 Engaging in reflective practice to assess and improve digital and managerial competence

6. Emerging Technology Integration	Scenario Thinking: Anticipating Future Implications	*6.1 Optimizing emerging tech use in operations & *6.3 Identifying integration challenges and success factors
6. Emerging Technology Integration	AI literacy = Digital literacy	*6.1 Optimizing emerging tech use in operations & *6.2 Evaluating technology maturity and usage
6. Emerging Technology Integration	Contextual Awareness and Big Picture Thinking	*6.1 Optimizing emerging tech use in operations & *6.3 Identifying integration challenges and success factors
6. Emerging Technology Integration	Business Model Innovation via Digital	*6.1 Optimizing emerging tech use in operations & *6.2 Evaluating technology maturity and usage
Existing Digital Competencies (DigComp), but new digital skills (from DETI)	**Digital Skills from DETI**	**Suggestion for presenting a skill in TSF**
2. Communication and Collaboration	Collaborative Leadership across Functions	*2.8 Cooperating and Collaborating across Functions
1. Information and Data Literacy	Trust in Digital-Physical Systems	*1.4 Reflective trust in digital systems based on data, modeling, and ethical standards
4. Safety	Ethical Reasoning (Responsible AI, data governance)	*4.5 Evaluating ethical risks and regulations in tech integration

University of Pavia

The results from the systematic literature review conducted by the University of Pavia are summarised in the table below.

Digital Competencies (aligned with DigComp)	Digital Skills from the SLR	Digital Skills as presented in DigComp
1. Information and Data Literacy	Digital use, Critical thinking	1.1. Browsing, searching and filtering data, information and digital content & 1.2. Evaluating data, information and digital content & 1.3. Managing data, information and digital content
2. Communication and Collaboration	Digital use, Digital communication, Digital collaboration	2.1. Interacting through digital technologies & 2.2. Sharing through digital technologies & 2.3. Engaging citizenship through digital technologies & 2.4. Collaborating through digital technologies & 2.6. Managing digital identity

3. Digital Content Creation	Digital content, Content creation	3.1. Developing digital content & 3.2. Integrating and re-elaborating digital content & 3.3. Copyright and licenses & 3.4. Programming
5. Problem Solving	Problem solving, Decision making, Critical thinking	5.1. Solving technical problems & 5.2. Identifying needs and technological responses & 5.3. Creatively using digital technology & 5.4. Identifying digital competence gaps
New Digital Competencies (as emerged from the Literature Review)	**Digital Skills from the Literature Review**	**Suggestion for presenting a skill in TSF**
****6. Emerging Technology Integration***	AI literacy = Digital literacy	*6.1 Optimizing emerging tech use in operations & *6.2 Evaluating technology maturity and usage
Existing Digital Competencies (DigComp), but new digital skills (from the literature review)	**Digital Skills from the Literature Review**	**Suggestion for presenting a skill in TSF**
2. Communication and Collaboration	Prompt engineering	*2.7 Facilitating human and machine interaction and collaboration in hybrid environments

Grenoble School of Management

The results from the workshops conducted by GEM are summarised in the table below. Competencies are presented in thematic blocks, from which relevant digital competencies have been extracted and organized accordingly.

Grenoble School of Management : **A** project aiming at enhancing current Master reference competences framework with novel digital skills, internally labelled: “Business Manager for Responsible Techno-Digital Transformation - Digi-Me"	
Competency block 1: Co-organize economic, geopolitical, technological, and digital monitoring for an organization and its ecosystem	1.1. Identify monitoring priorities in line with the company's strategic positioning, integrating CSR and ethical dimensions to guide and optimize the organization and resources allocated to monitoring
	1.2. Identify monitoring priorities in line with the company's strategic positioning, integrating CSR and ethical dimensions to guide and optimize the organization and resources allocated to monitoring
	1.3. Organize the monitoring process, defining tools and schedules according to changes in the environment and the organization's needs.
	1.4. Report to the relevant departments on trends, threats and opportunities to be monitored in

	relation to the parent organization, in order to integrate this information and analysis into strategic choices.
Competency block 2: Define an organization's strategy in the face of the transformative potential of technology, digitalization, and CSR	2.1. Characterize the ecosystem in which the organization operates in order to seize opportunities and minimize risks, and identify resources and networks
	2.2. Assess the organization's technological, digital, and CSR maturity in order to take these elements into account when identifying strategic options and challenges, based on the levels and practices observed within the sector
	2.3. Lead or co-lead the development of an international strategic vision by setting objectives and ensuring meaningful alignment, while considering the economic, social, and ethical impacts of decisions
	2.4.Examine the value creation model and the types of performance indicators used, to support decision-making—particularly in light of technological, digital, CSR, and ethical challenges
Competency Block 3: Assess an organization's financial situation and investment capacity	3.1. Analyse the cash flow statement to assess the company's financial health
	3.2. Analyse key financial ratios (profitability, liquidity, working capital and working capital requirements, debt, return on investment, etc.) to inform strategic decision-making
Competency block 4: Adapt team management to new organizational structures	4.1. Facilitate team collaboration by optimizing collective intelligence processes and human/machine hybridization across tasks and activities, while ensuring the inclusion of diverse employee profiles.
	4.2. Support change management by integrating new work structures and team management approaches to evolve practices in alignment with necessary adaptations and the chosen business model.
	4.3. Manage the specific leadership challenges associated with multidisciplinary teams composed largely of technoscientific profiles.
	4.4. Advise and negotiate with both teams and business partners in intercultural contexts, while upholding ethical and professional standards
Competency Block 5: Communicate with multidisciplinary teams on managerial and technoscientific topics	5.1. Develop self-awareness (action and communication styles, etc.) by regularly engaging in reflective practices regarding professional and managerial actions, and by assessing skills in light of the evolution of the profession, tools, organization, and society, in order to define areas for improvement

	5.2. Adapt both written and oral communication, with the help of new digital tools, to different stakeholders and professional contexts (meeting facilitation, interviews, arguments in interpersonal or group situations) to ensure clear messaging and maintain the desired quality of relationships
	5.3. Understand the main characteristics of problem-solving approaches, sizing, and simulation/evaluation methods used by engineers, as well as the key tools, in order to foster constructive exchanges
Competency block 6: Define the operational areas, processes, and tools for deploying the strategy within a specific scope of activities	6.1. Identify the specific rules and standards for the activity and professions within the defined scope in order to establish the required safeguards and implementation guidelines, including re-evaluating existing organizational structures and processes, and updating the necessary skills
	6.2. Implement policies, processes, and practices that translate strategic directions and priorities into action plans, incorporating AI tools
	6.3. Optimize the use of data systems and technologies (IS, blockchain, AI, etc.) in operations management, ensuring attention to ethics, standards, and legal frameworks
	6.4. Anticipate crisis situations by structuring and organizing appropriate crisis management processes
Competency Block 7: Mobilize the expertise of an emerging technology and its ecosystem in terms of its strategic implications	7.1. Characterize the maturity and usage of the technology
	7.2. Define the technology's ecosystem, including its key specialists and development centres
	7.3. Inventory the main challenges of its integration and identify key success factors
	7.4. Assess the CSR and ethical risks and opportunities of the technology, along with regulatory constraints, compared to one or more use cases
Competency Block 8: Drive investment decisions, operational performance, and risk management of international activities using data and new technologies, with a focus on continuous improvement	8.1. Evaluate investment opportunities and their profitability in relation to the proposed strategy
	8.2. Manage both financial and non-financial indicators to guide operational activities specific to the relevant professions and functions, assessing the effects and results of the action plans undertaken
	8.3. Determine priorities and risk management approaches based on risk mapping and qualifications, in order to reduce the exposure of the business and its activities to those risks

Competency block 9: Deploy innovation processes tailored to the technological and societal characteristics of the project	9.1. Promote and lead innovation processes within the scope of activity, in alignment with the company's innovation policy
	9.2. Define and manage innovation projects according to methods, processes, and tools suited to the technologies and sectors involved
	9.3. Foster entrepreneurial leadership practices, rather than managerial approaches, to promote innovation and transformation
Competency Block 10: Conduct and defend in-depth studies on a strategic management topic based on scientific reasoning and highly specialized knowledge	10.1. Identify, select, and critically analyse various sources of highly specialized knowledge to document a topic and synthesize this data for its exploitation
	10.2. Define and address a strategic management issue by applying a scientific approach, resources, methodologies, and reasoning in order to produce a written document with structured, in-depth, and reliable analysis, offering original proposals for the activity, company, or sector
	10.3. Defend, in writing, the proposed analysis and chosen approach before various audiences, convincing them of the conclusions and recommendations, in either French or a foreign language

Digital competencies and skills extracted from DETI workshops' results		
Digital Competencies (aligned with DigComp)	**Digital Skills from DETI (Reference in Competency Block)**	**Digital Skills as presented in DigComp**
1. Information and Data Literacy	1.2 Identify formal and informal sources to ensure information quality.	1.2. Evaluating data, information and digital content
	1.4 Report on trends and opportunities for strategic integration.	1.1. Browsing, searching and filtering data, information and digital content & 1.3. Managing data, information and digital content
	10.1 Critically analyze specialized sources and synthesize data.	1.2. Evaluating data, information and digital content
2. Communication and Collaboration	4.4 Advise and negotiate with diverse teams in intercultural contexts.	2.4. Collaborating through digital technologies & 2.6. Managing digital identity
	5.2 Adapt written/oral communication using digital tools for various stakeholders.	2.1. Interacting through digital technologies & 2.5. Netiquette
	10.3 Defend strategic analysis in written/oral form in multiple languages.	2.1. Interacting through digital technologies & 2.2. Sharing through digital technologies

3. Digital Content Creation	6.2 Implement processes and practices translating strategy with AI tools.	3.4. Programming & 3.2. Integrating and re-elaborating digital content
	9.2 Define and manage innovation projects with suitable methods and tools.	3.1. Developing digital content & 3.3. Copyright and licenses
4. Safety	6.3 Optimize data systems (IS, blockchain, AI) while considering ethics, standards, and legal frameworks.	4.3. Protecting health and well-being & 4.4. Protecting the environment & 4.2. Protecting personal data and privacy
5. Problem Solving	5.3 Understand engineering methods for constructive exchanges.	5.1. Solving technical problems
	10.2 Address strategic issues using scientific reasoning and methods.	5.2. Identifying needs and technological responses & 5.3. Creatively using digital technology
New Digital Competencies (as emerged from GEM's DETI Workshops)	**Digital Skills from DETI (Reference in Managerial Competencies - GEM)**	**Suggestion for presenting a skill in TSF**
***6. Emerging Technology Integration**	6.3 Optimize AI, blockchain, and IS use in operations.	*6.1 Optimizing emerging tech use in operations
	7.1 Evaluate technology maturity and usage.	*6.2 Evaluating technology maturity and usage
	7.3 Identify integration challenges and success factors.	*6.3 Identifying integration challenges and success factors
***7. Digital Self-Development and Reflective Practice**	5.1 Engage in reflective practice to assess and improve digital and managerial competence.	*7.1 Engaging in reflective practice to assess and improve digital and managerial competence
Existing Digital Competencies (DigComp), but new digital skills (from GEM's DETI Workshops)	**Digital Skills from DETI (Reference in Managerial Competencies - GEM)**	**Suggestion for presenting a skill in TSF**
2. Communication and Collaboration	4.1 Facilitate collaboration in hybrid environments (human + machine), ensuring inclusion.	*2.7 Facilitating human and machine interaction and collaboration in hybrid environments
4. Safety	7.4 Evaluate ethical risks and regulations in tech integration	*4.5 Evaluating ethical risks and regulations in tech integration

Annex 7. Digital competencies and their definitions

Digital Competence	Definition
1. Information and Data Literacy	Ability to articulate information needs, search for data, information, and content in digital environments, access them, and navigate between them. The ability to critically evaluate the relevance, reliability, and credibility of information and data, as well as to manage and organize them effectively. To organize, store and retrieve data, information, and content in digital environments. To organize and process them in a structured environment (Vuorikari et al., 2022; Furtáková, 2024).
2. Communication and Collaboration	The use of digital technologies to interact, share and collaborate. Communication refers to the ability to interact, share resources, and exchange information using digital technologies. It encompasses various forms of digital communication, such as email, messaging, social media and video conferencing, and emphasizes the importance of clear and effective communication in a digital context. Collaboration refers to the ability to work effectively with others using digital tools and resources. It also includes the ability to engage in collective knowledge creation and problem-solving using digital technologies (Vuorikari et al., 2022; Furtáková, 2024)
3. Digital Content Creation	The processes of creating, editing and integrating different digital content to produce new, original and relevant knowledge and resources. That can include the creation and editing of content such as text, images, sound, video, animation and interactive media for digital platforms and environments. It also includes a wide range of activities from designing graphics and creating videos to developing interactive applications and writing digital articles (Vuorikari et al., 2022; Furtáková, 2024).
4. Safety	Ability to protect oneself and others from potential dangers in the digital environments, to understand risks and threats in the digital environments, and have due regard for reliability and privacy. This includes being able to

	avoid health risks and threats to physical and psychological well-being while using digital technologies, as well as knowing about safety and security measures in digital environments (Vuorikari et al., 2022; Furtáková, 2024)
5. Problem Solving	Ability to identify, analyse and solve problems in a digital context. It includes the ability to identify and solve technical problems when operating devices and using digital environments (from trouble-shooting simple problems to solving more complex problems). Ability to discuss ways to protect the environment from the impact of digital technologies and their use, as well as to choose the most appropriate solutions to protect the environment from the impact of digital technologies and their use. The area emphasizes the importance of developing critical thinking skills and the ability to apply problem-solving strategies in digital contexts (Vuorikari et al., 2022; Furtáková, 2024)
6. Emerging Technology Integration	Ability to assess, adopt, and optimize technologies (e.g., AI, XR, digital twins) within operational, strategic, or managerial contexts, in alignment with organizational goals and ethical standards. Ability to apply emerging technologies to enhance processes, productivity, decision-making, and collaboration. Assess the maturity, suitability, and potential of emerging technologies using structured evaluation tools (e.g., Gartner Hype Cycle). Identify enablers and barriers for successful integration of emerging technologies into organizations, projects, or learning ecosystems (JISC, 2023)
7. Digital Self-Development and Reflective Practice	Ability to consciously monitor, evaluate and enhance one's digital and managerial competence through reflective practice, goal-setting, and engagement in lifelong learning communities. Use reflection methods to identify strengths and gaps in digital and managerial competencies, and take international steps to address them (JISC, 2023).