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AI-Enabled Manufacturing for Twin Transition

Grant Agreement No 101191605

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Document Sheet

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Abbreviations

Abbreviation	Definition
AI	Artificial Intelligence
CV	Computer Vision
EDIH	European Digital Innovation Hub
ERP	Enterprise Resource Planning
ESG	Environmental, Social, and Governance
HPC	High-Performance Computing
ICI	The Istanbul Chamber of Industry
IoT	Internet of Things
KPI	Key Performance Indicator
KVKK	Turkish Personal Data Protection Law
LCA	Life Cycle Assessment
LE	Large Enterprise
MES	Manufacturing Execution System
NLP	Natural Language Processing
OECD	The Organization for Economic Co-operation and Development
PLC	Programmable Logic Controller
RPA	Robotic Process Automation
SCADA	Supervisory Control and Data Acquisition
SME	Small and Medium-Sized Enterprise
SO	Specific Objective
WP	Work Package

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Publishable Summary

This deliverable presents a foundational analysis to guide the training and upskilling services of AI EDIH Türkiye, which supports the digital and green transformation of manufacturing SMEs in Türkiye through Artificial Intelligence (AI), High-Performance Computing (HPC), and sustainability. Led by İstanbul Technical University under WP4 (Trainings and Upskilling), the study integrates a demand-driven survey of SMEs and a mapping of training offers from consortium partners.

The survey assessed training needs and priorities across AI, Data Science, Digital Transformation, and Sustainability domains, along with firms' digital maturity, sectoral characteristics, and preferred training formats. The findings were matched with the existing training capacity of EDIH partners to identify alignment and gaps.

The results of this analysis form the basis for designing modular, targeted, and accessible training programs aligned with the Digital Europe Programme objectives and contribute to increasing AI adoption, digital skills, and innovation capacity among SMEs.

1. Introduction

This document (D4.1) aims to accelerate the digital and green transformation of manufacturing SMEs in Türkiye, with a particular focus on AI, High-Performance Computing (HPC), and sustainability. WP4 addresses Specific Objective 3 (SO3) of the project—namely, the upskilling of the workforce to enable effective utilization of digital transformation tools and processes through targeted and responsive training programmes.

Aligned with the overarching mission of AI EDIH Türkiye to establish a one-stop shop for digital innovation services in the Istanbul region and beyond, D4.1 sets out to identify the existing capacity gaps within SMEs, understand their thematic training priorities, and map relevant stakeholders who can support the delivery of tailored upskilling initiatives. The insights gained through this task are critical to designing training programs that respond to real sectoral needs and reflect the digital maturity spectrum across firms.

The methodology followed in this study relies on both demand-side and supply-side analyses. The demand side is informed by a needs analysis survey targeting SMEs, focusing on four key domains: AI, Data Science, Digital Transformation, and Sustainability. The survey also captures firm-specific characteristics such as size, sector, and digital readiness, as well as their preferences in training delivery formats and durations. On the supply side, the existing capacity and training proposals of project partners are systematically analyzed (mapped) to assess alignment with the identified needs.

D4.1 contributes to the broader objectives of the Digital Europe Programme and the Digital Decade Policy Programme 2030 by supporting AI uptake and advanced digital skills development. Moreover, the results directly inform the design and implementation of WP4's subsequent activities, particularly Deliverables

D4.2 and D4.3, which will document the content and outcomes of technology and executive training modules.

In sum, D4.1 provides a robust evidence base for structuring demand-driven and impact-oriented training pathways, reinforcing AI EDIH Türkiye's mission to serve as a key enabler of Türkiye's digital transition in the manufacturing sector.

2. Background

The digital and green transformation of SMEs is critical for economic competitiveness and innovation. Globally, SMEs represent around 90% of firms but often lag in digitization due to limited resources, skill shortages, and low strategic orientation toward digital adoption (OECD, 2021; Kergroach, S.2021). In Türkiye, these challenges are particularly acute—especially in under-capitalised SMEs and technology development zones—where sustainability and advanced digital technologies remain underutilized due to high investment requirements and skill gaps (İncekara et al, 2023).

Recent research evidence on the textile and clothing sectors in Türkiye, for example, shows that organizational learning is a key enabler of digitalization and internationalisation for SMEs. Divrik and Baykal (2024) found digital transformation accelerated post-COVID, but was driven primarily by internal learning capabilities embedded in firm culture and strategy. This underscores the importance of mapping providers—like EDIH partners, universities, and specialized training centers—that support organizational learning with structured skill development.

Earlier studies (Kutlu and Özturan, 2008) reveal that Turkish SMEs initially adopt IT for operational tasks (e.g. accounting), and gradually invest in internal IT skills, indicating progression toward more complex digital systems. This reinforces the need for layered, incremental training programmes, moving from basic IT competencies to advanced data and AI capabilities.

Empirical evidence from Türkiye confirms a modest but statistically significant relationship between AI adoption and perceived performance in SMEs based in Technology Development Zones (Caner, 2024). While indicating promise, the limited scope of AI use suggests room for targeted capacity building—particularly digital skills in AI and data analytics that the current study seeks to address.

Internationally, the OECD Going Digital Toolkit outlines essential policy actions for SME transformation: fostering uptake, providing training, strengthening managerial capacities, and facilitating access to finance (OECD, 2021; Kergroach, S.2021). In Türkiye, the national government's support for digitalization—exemplified by the Digital Transformation Office and incentives for digital skills—highlights an institutional environment conducive to leveraged training offerings. Sector-specific studies point to financial resources and green innovation strategies as critical drivers that can accelerate AI adoption among Turkish SMEs, particularly in green technology industries such as construction (Farmanesh et al, 2025; İncekara et al, 2025). This aligns well with our project's emphasis on sustainable AI and digital training modules.

Based on literature, several themes directly inform the methodological orientation of D4.1, in particular the incremental adoption - SMEs benefit from starting with routine digital tools before progressing to advanced AI—mirrored in survey instruments with layered skill domains (IT, data analytics, AI, sustainability; and organizational learning and internal competence **-** Turkish research highlights the vital role of learning ecosystems—supporting our stakeholder mapping of universities, tech clusters, EDIH providers, and consultancy networks. Accordingly, D4.1 employs a dual methodology: (1) a demand-led survey evaluating digital maturity across thematic areas (AI, data science, digital transformation, sustainability), and (2) an ecosystem mapping of training providers, ensuring both empirical relevance and strategic coherence and while addressing the specific needs and structures of Turkish SMEs.

3. Method

This study employed a quantitative survey method to assess the digital transformation and AI training needs of enterprises, with a focus on SMEs. The objective was to identify capacity gaps and inform the design of AI EDIH Türkiye's *Trainings and upskilling* for capacity-building services. The methodological approach followed a three-step process to develop a framework for the training program:

- *Demand Analysis* **-** A structured online questionnaire titled "Artificial Intelligence-Based Digital Transformation Needs Analysis Survey" *(Yapay Zekâ Tabanlı Dijital Dönüşüm İhtiyaç Analizi Anketi)* was designed and disseminated to assess the digital maturity levels, technological adoption, and specific training needs of enterprises (see Annex).

The questionnaire (see *Table 1*) was designed to capture insights into:

- Organizational characteristics (e.g., company size, sector, digital maturity)
- Current usage and competencies related to digital technologies
- Training preferences and needs across AI, Data Science, Digital Transformation, and Sustainability domains
- Preferred learning formats and durations

The questionnaire was disseminated through the mailing list of MEXT, Istanbul Chamber of Industry (ICI), and social media channels of the AI-EDIH Türkiye Project, MEXT, ICI, and the Istanbul Technical University Project Team channels. A total of 116 responses were received, out of which 77 were from SMEs, while the remaining were submitted by large enterprises (LEs) (see *Table 2* through *Table 4* for the composition of the firms). The inclusion of LEs in the sample was intentional, serving as a statistical benchmark to better differentiate and emphasize the specific needs of SMEs. Respondents were assured of full confidentiality in compliance with the Turkish Personal Data Protection Law (KVKK) and GDPR. The data was collected in June 2025, requiring approximately 4-5 minutes to complete the survey.

- *Supply Analysis* - The internal capabilities of consortium stakeholders, including the training offers provided by project partners, were mapped to assess their readiness and capacity to deliver training aligned with the identified needs.

- *Training Program Design* - Key elements of the training framework—including thematic areas, target groups, delivery formats, and preferred durations—were synthesized based on the findings from the analyses.

Table 3-1: Questionnaire design

Category	Variables	Operationalization of variables
Respondent profile	• Q1 through Q4 - Name & contact info • Q7 – Role in the company • Respondent status	• Name & surname, email address • Respondents were asked to specify their current role in the company (Executive, Director, Manager, Technical Specialist / Engineer, IT personnel, Field / Production Staff, Office Worker, Other) • Respondents were asked to specify their status when filling out the questionnaire (as a company representative, as an individual employee)
Company profile	• Q1 - Name • Q5 - Sector • Q6 - Size (micro, small, medium)	• Company name • Main sector of activity • Number of employees (Micro <10, Small 10–49, Medium 50–249, Large>250)
Digital maturity	• Q9 - Perceived digital maturity level • Q10 - Purpose of using digital technologies • Q11 - Digital competency level of employees • Q12 - Methods to improve the digital skills of employees	• Respondents to were asked to specify the digital maturity level of the company (Basic – Only fundamental IT tools are in use; Developing – Some digital tools are actively used; Advanced – Digital systems are integrated into processes; Leading – AI and advanced analytics are used in strategic decisions) • Respondents were asked to specify the purpose of using digital technologies in the company (Customer communication - CRM, website, social media; Accounting processes - invoicing, inventory; Collaborating with other companies; Automating repetitive and risky tasks; Designing new products and services; Forecasting future decisions and actions; HR operations - digital payroll, leave tracking, room booking; other) • Respondents were asked to specify the digital competency level of employees (Expert - Advanced digital technology experts; Active user - Professional staff actively using digital tools; Trainer - Employees who train/mentor others in digital tech; Basic user - Basic digital tool users only; None - No employee with digital competency) • Respondents were asked to specify the ways/channels used to improve digital competencies in the company (self-paced learning, Peer teaching by experienced staff, In-house training programs, Online platforms such as

		Udemy/Coursera, Certified training programs, Project-based learning, Other)
Training needs	• Q13 & Q14 - Main beneficiaries of trainings on AI, digital transformation, and sustainability • Q15 through Q22 - Demand for training topics & sub-topics • Q23 - Preferred training formats • Q24 - Preferred training durations	• Respondents were asked to specify which departments would benefit most from the training on AI, Digital Transformation, or Sustainability • Respondents were asked to specify the topics of interest for training (max. 3 topics) • Respondents were asked to specify the preferred training formats (Multiple selections allowed - In-person; On-site workshops; Live online sessions; Self-paced e-learning; Blended learning (online + in-person); Hands-on training) • Respondents were asked to specify the preferred duration of training (multiple selections allowed - 1–2-hour short webinar; Half day; Full day; Multi-day program; After work; Full-day weekend sessions; Other)

Table 3.2 below presents the demographic and organizational profile of the survey respondents, providing a snapshot of the firms and individuals who contributed to the needs analysis.

Table 3-2: Profile of respondents

Category	Variables	Number of respondents	Percentage (%)
Role in the company	Manager	79	68
	Employee	37	32
Status as a respondent	Company representative	85	73
	Individual employee	31	27
Company profile	Sector		
	Industry & manufacturing	57	49
	Energy and infrastructure	10	9
	Building & construction	12	10
	Technology	19	16
	Other	18	16
	Size		
	Micro	26	22
	Small	21	18
	Medium	30	26
	Large	31	34

Tables 3.3 and 3.4 provide a detailed breakdown of the sectoral distribution of respondents, disaggregated by enterprise type (SMEs vs. LEs). This classification helps highlight the relative representation of different industries in the survey and allows for comparative analysis of training needs across sectors.

Table 3-3: Sector-Based Distribution of Respondents According to Enterprise Type (LEs vs. SMEs)

	Sector					
	Industry & manufacturing	**Energy and infrastructure**	**Building & construction**	**Technology**	**Other**	**Total**
Large Enterprises	25 (%44)	3 (%30)	2 (%17)	2 (%11)	7 (%39)	39 (%34)
SMEs	32 (%56)	7 (%70)	10 (%83)	17 (%89)	11 (%61)	77 (%66)

Table 3-4: Role-Based Distribution of Respondents According to Enterprise Type (LEs vs. SMEs)

	Role in the company		
	Employee	**Manager**	**Total**
Large Enterprises	16 (%43)	23 (%29)	39 (%34)
SMEs	21 (%57)	56 (%71)	77 (%66)

Data from questionnaire were statistically analyzed to assess the digital maturity levels, technological adoption, and specific training needs of SMEs. Authors used various versions of Python and AI tools to analyze, visualize and synthesize data from the field.

The capacity of the internal stakeholders was identified (mapped) to respond to the needs of the SMEs. For this purpose, AI EDIH TÜRKIYE Service Catalog (see Grant Agreement) was analyzed to map the training proposals of the project partners (see *Table 5*, which will be transformed to a course/training catalog before the delivery of the trainings).

Table 3-5: Catalogue structure of leaning offers by project partners

No.	Variable Name	Description
1	Course Title	Full name of the training or program
2	Offering Partner(s)	Institution(s) delivering the course (e.g., ITU, ICI, Bilkent), TÜBİTAK-Bilgem
3	Focus Area	One of: Digital Transformation, Artificial Intelligence, Data Science, Sustainability
4	Sub-Thematic Tags	Specific subdomains covered (e.g., NLP, Computer Vision, ESG, Circular Economy, IoT)
5	Training Type	Format such as workshop, lecture series, MBA-style program, blended learning, etc.
6	Delivery Mode	In-person, online, hybrid
7	Duration	Duration in hours or days (e.g., "2 Days, 16 Hours")
8	Delivery Frequency	Number of times offered per year, or custom scheduling (e.g., "6 times/year", "upon request")
9	Target Audience	e.g., SMEs, startups, public employees, engineers, managers, etc.
10	Learning Outcomes	Main competencies and skills to be gained

No.	Variable Name	Description
11	Prerequisites/Level	Entry-level, technical, managerial, etc. (e.g., "Mid-Level Managers", "Technical Teams")
12	Fee Structure	Price in EUR or TL, per person or group, with indication of VAT or additional costs
13	Maximum Participants	Group size limit if specified (e.g., 20 people, 30 max)
14	Certification	Whether certification or credential is provided
15	Expected Impact	Contribution to EDIH goals such as upskilling, innovation, productivity
16	Customization Option	Whether content can be tailored to company-specific needs
17	Application/Registration Process	How and when to register (e.g., 1 month in advance)
18	Tools & Methods	Mentioned tools, technologies, or frameworks (e.g., Python, SCADA, Agile, HPI Design Thinking)

Several *limitations and assumptions* should be acknowledged to contextualize the results and ensure appropriate interpretation: (1) while efforts were made to reach a broad audience through the Istanbul Chamber of Industry (ICI), the resulting sample (116 responses) may not be fully representative of the entire SME landscape; (2) the survey relied on self-reported assessments of digital maturity, training needs, and competency levels. Such responses may be subject to bias due to social desirability, lack of technical understanding, or optimism bias, particularly among non-technical respondents; (3) the survey captures a snapshot of organizational needs at a specific point in time. However, digital and sustainability-related capacity needs are dynamic and may evolve rapidly in response to technological advances, policy changes, or external shocks (e.g., economic downturns, regulatory shifts); this requires additional measures over the life cycle of the Project; and (4) the stakeholder and training offer mapping is primarily based on consortium members' documented services and institutional knowledge at the time of reporting. Training offerings from non-consortium actors or emerging providers (e.g. startups, international platforms) may not be fully captured, also requiring additional inputs from the consortium members over time.

To ensure sustained relevance and responsiveness of the training design, the findings presented in this delivery should be considered as a foundational snapshot rather than a static assessment. Given the dynamic nature of technological adoption and evolving SME needs, follow-up qualitative methods—such as semi-structured interviews, focus groups, and expert panels—can be considered to complement the quantitative survey results with deeper contextual insights. Furthermore, a longitudinal tracking mechanism will be necessary to capture changes in digital maturity, training demand, and implementation outcomes over the course of the project. To this end, the needs analysis can be updated through biannual surveys, stakeholder workshops, or focus group meetings. These updates will feed into the iterative refinement of the training catalogue and support adaptive program design aligned with shifting sectoral, policy, and technological conditions.

4. Analysis of Demand - Training Needs

This chapter presents the results on digital maturity levels, technological adoption, and specific training needs of enterprises. It follows a structured approach: first identifying the training needs of SMEs, then analyzing their maturity levels and adoption of relevant technologies, and finally detailing the specific training topics required. Sub-chapters describe both the current situation across four focus areas—digitalization, artificial intelligence, data science, and sustainability—and the corresponding demand for training.

4.1 Digital Transformation

The survey results show that SMEs primarily use digital technologies for customer communication, accounting, and collaboration, with fewer applications in predictive analytics or automation. Digital competency levels vary widely, with a notable proportion of firms reporting only basic skills. Common methods for improving digital skills include peer teaching and in-house training, while certified programs and online platforms are less utilized. Larger firms and those with higher digital maturity levels report more advanced digital usage and training practices. Training demand is concentrated in ERP integration, IoT, and cybersecurity, with hands-on and sector-specific applications strongly preferred.

4.1.1 Current State and Maturity for Digital Transformation

Figures 4.1 to 4.9 provide a comprehensive view of how enterprises adopt digital technologies, employee competency levels, and methods used for upskilling. Across sectors (Fig. 4.1), digital tools are primarily used for communication, accounting, and collaboration. Figures 4.2 and 4.5 show that a significant share of employees possess only basic digital skills, while a smaller portion exhibit advanced proficiency. Peer-led learning and in-house training (Fig. 4.3 and 4.6) are the most common methods of digital upskilling. Figures 4.4 and 4.7 reveal that larger firms and those with higher digital maturity utilize technologies more broadly, including in advanced applications such as product design and forecasting. Competency levels and training methods (Figs. 4.8 and 4.9) correlate positively with perceived digital maturity, indicating a virtuous cycle for more mature firms.

For manufacturing SMEs, the figures confirm a foundational but underdeveloped adoption of digital transformation. While basic tools like CRM or invoicing software are common, advanced practices like real-time monitoring or digital twins are rarely implemented. The heavy reliance on informal training channels and lack of digital specialists hampers progress toward Industry 4.0 readiness. Sector-specific, production-oriented training modules supported by external expertise could address these gaps, particularly in IoT, ERP integration, and cybersecurity.

Figure 4-1: Purpose of using digital technologies (according to sector)

Figure 4-2: Digital competency level of employees (according to sector)

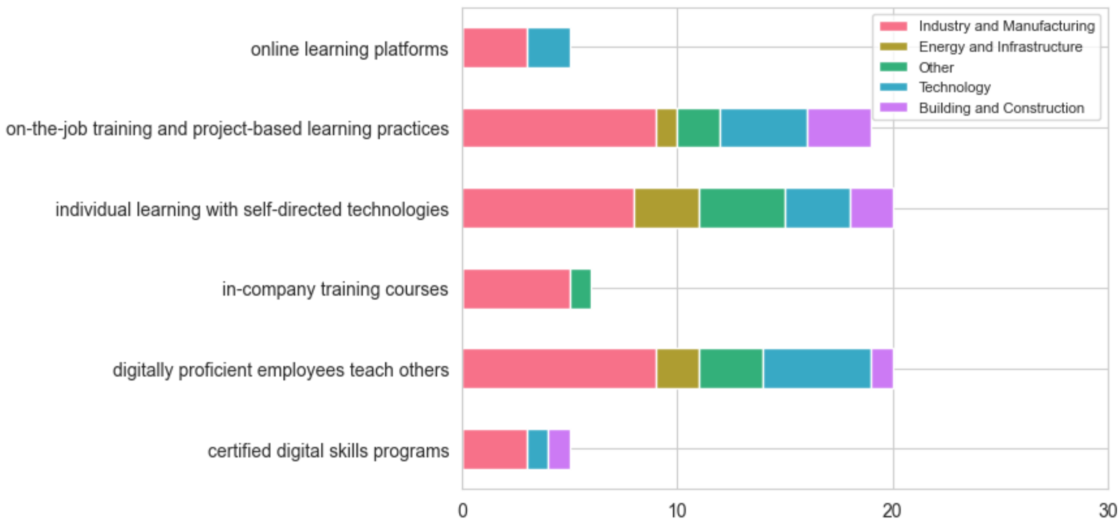

Figure 4-3: Methods to improve the digital skills of employees (according to sector)

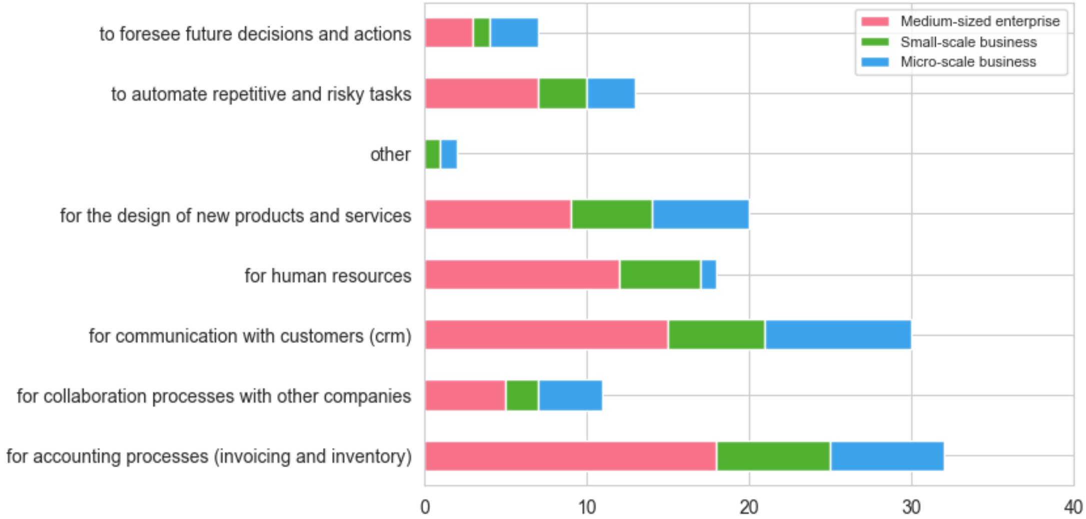

Figure 4-4: Purpose of using digital technologies (according to size)

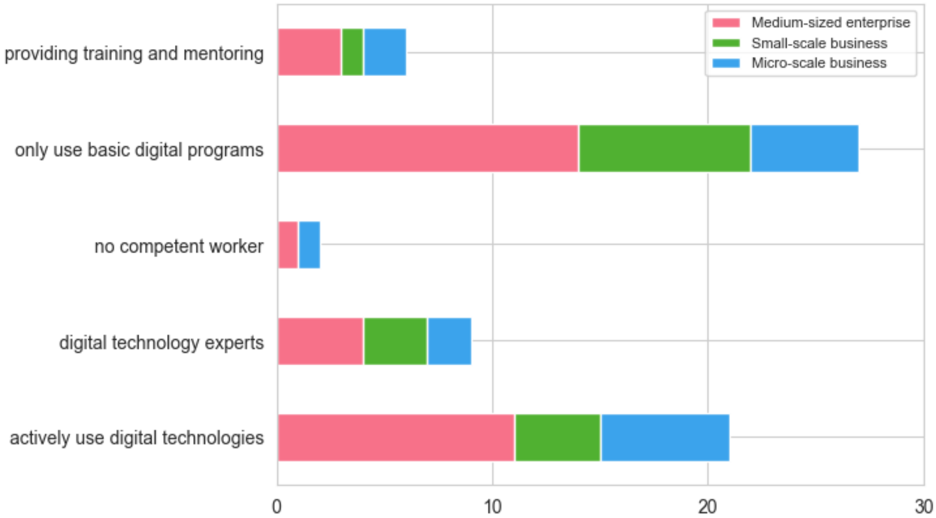

Figure 4-5: Digital competency level of employees (according to size)

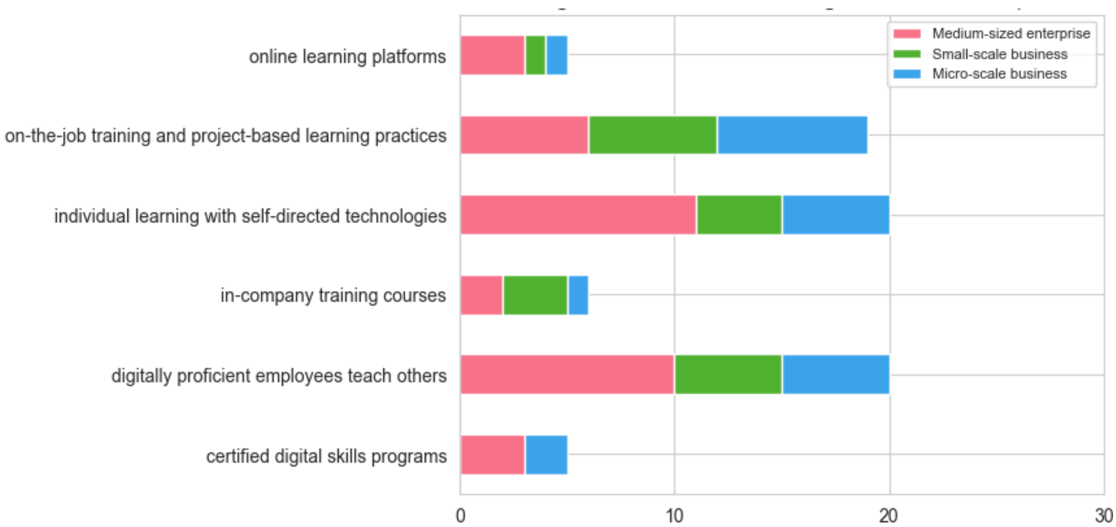

Figure 4-6: Methods to improve the digital skills of employees (according to sector)

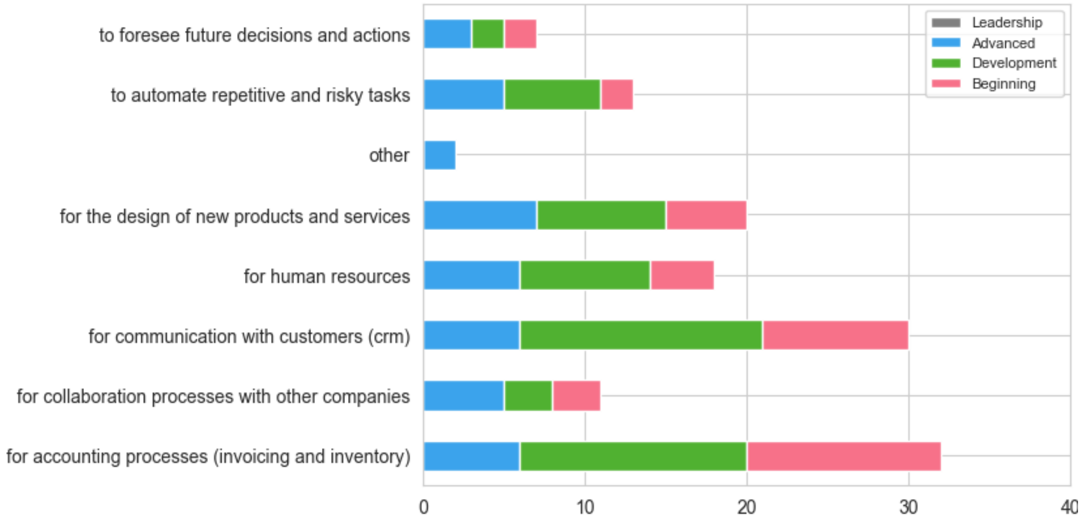

Figure 4-7: Purpose of using digital technologies (according to perceived digital maturity level)

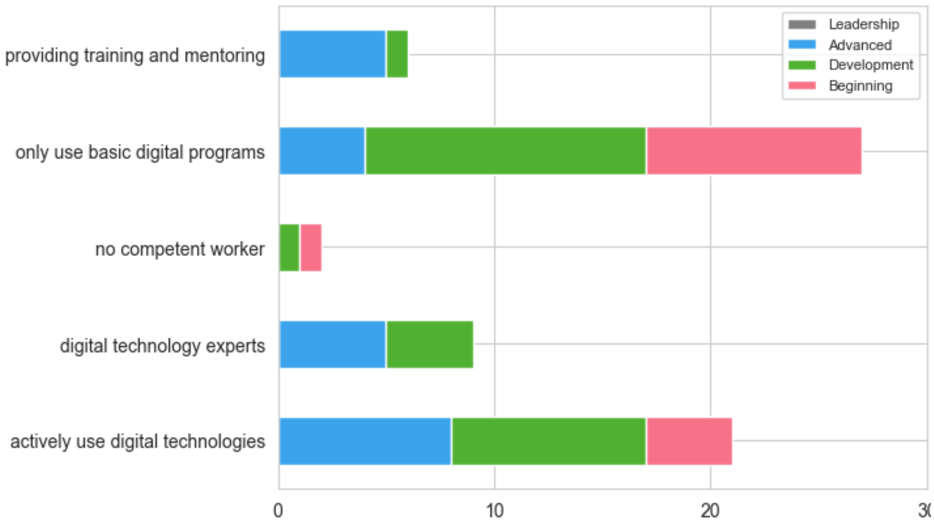

Figure 4-8: Digital competency level of employees (according to perceived digital maturity level)

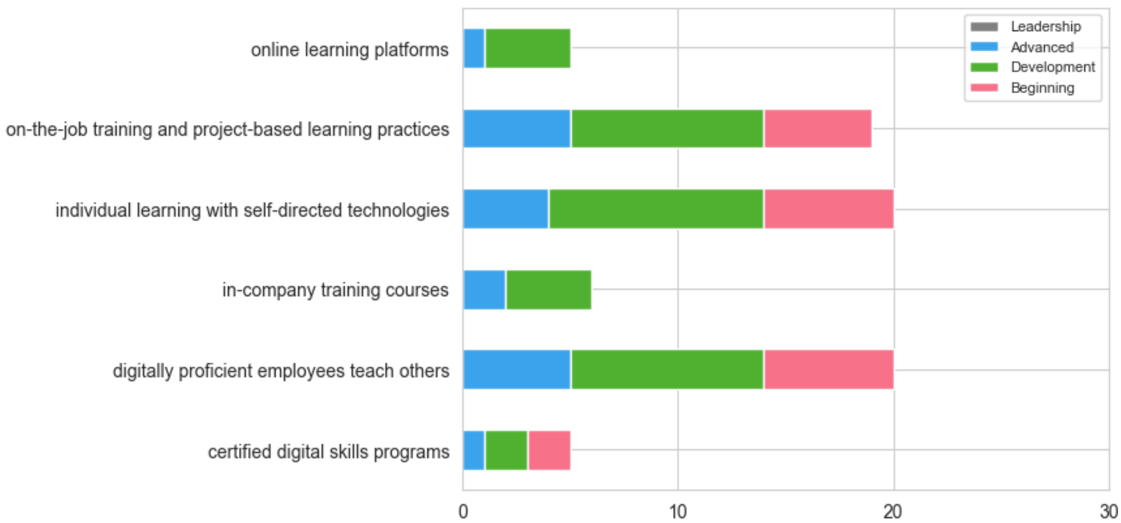

Figure 4-9: Methods to improve the digital skills of employees (according to perceived digital maturity level)

4.1.2 Training Needs for Digital Transformation

Figures 4.10 to 4.15 depict both general and detailed training needs across firm size, sector, and maturity. ERP/MES systems, IoT, and cybersecurity are the top-priority areas (Figs. 4.10–4.12). When broken down into sub-topics (Figs. 4.13–4.15), respondents emphasize production process digitization, real-time monitoring, and supply chain digitization. Companies with higher maturity express interest in more complex domains such as remote intervention and digital factory integration.

Manufacturing SMEs show strong demand for training that supports operational efficiency and resilience. Their emphasis on ERP/MES, cybersecurity, and IoT highlights the urgent need to modernize production environments. Training programs tailored to SME-specific realities should focus on practical implementations—such as secure data exchange in supply chains and sensor-based monitoring—delivered via hands-on, modular formats.

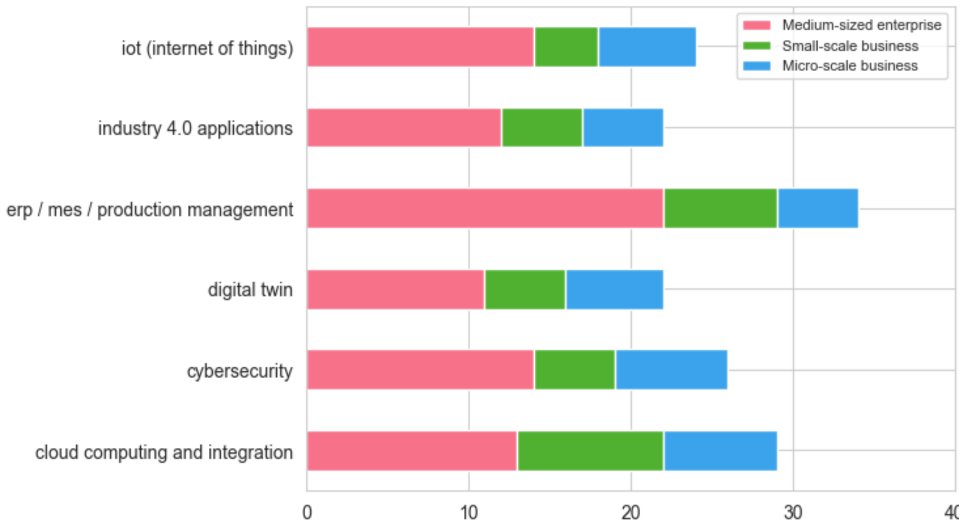

Figure 4-10: Demand for training topics (according to size)

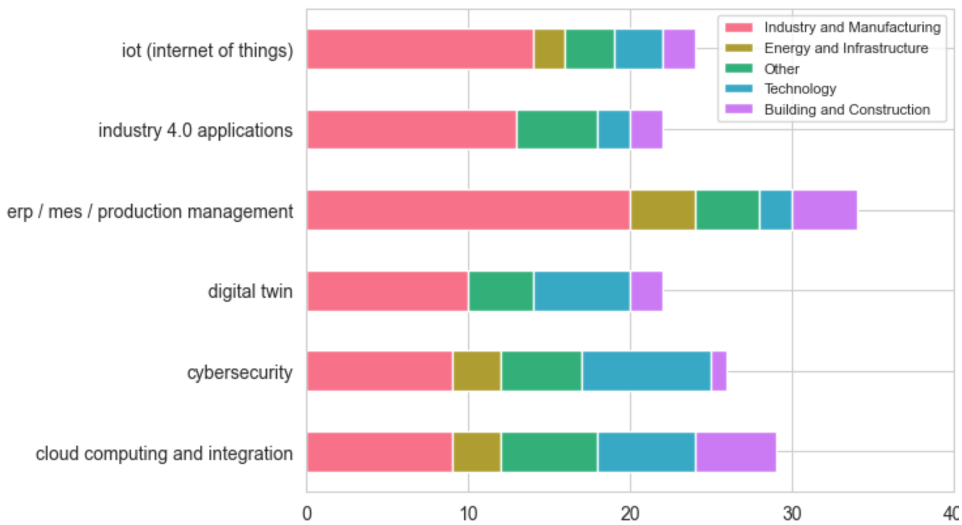

Figure 4-11: Demand for training topics (according to sector)

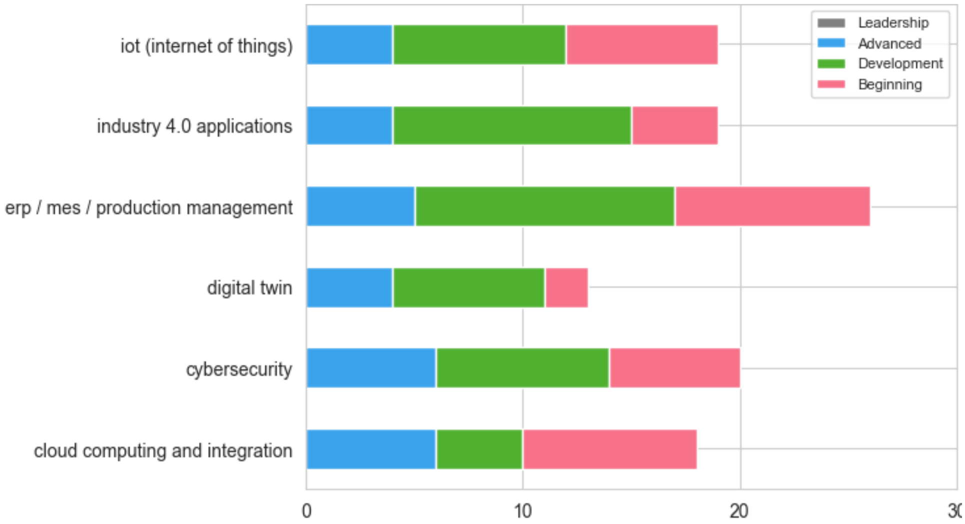

Figure 4-12:Demand for training topics (according to perceived digital maturity level)

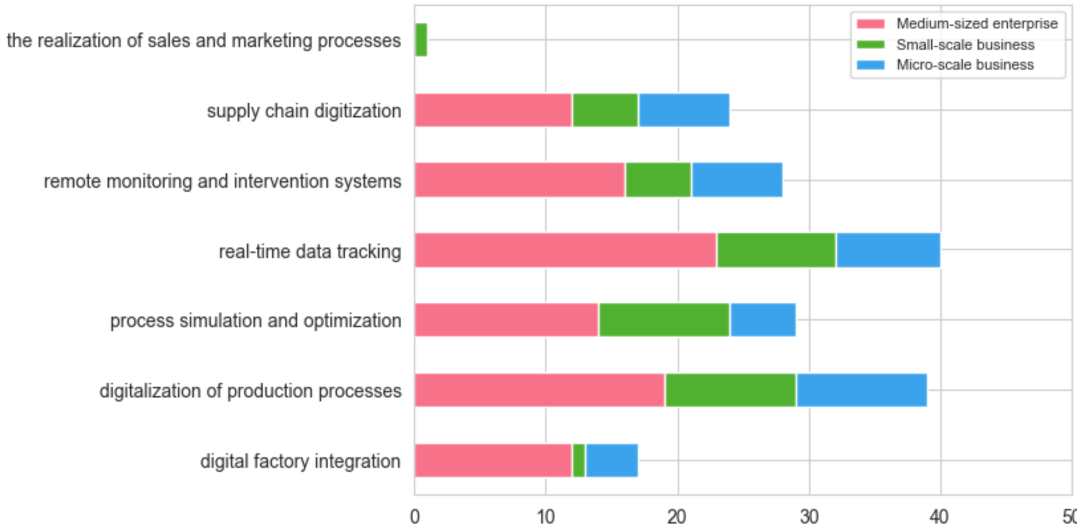

Figure 4-13: Demand for training sub-topics (according to size)

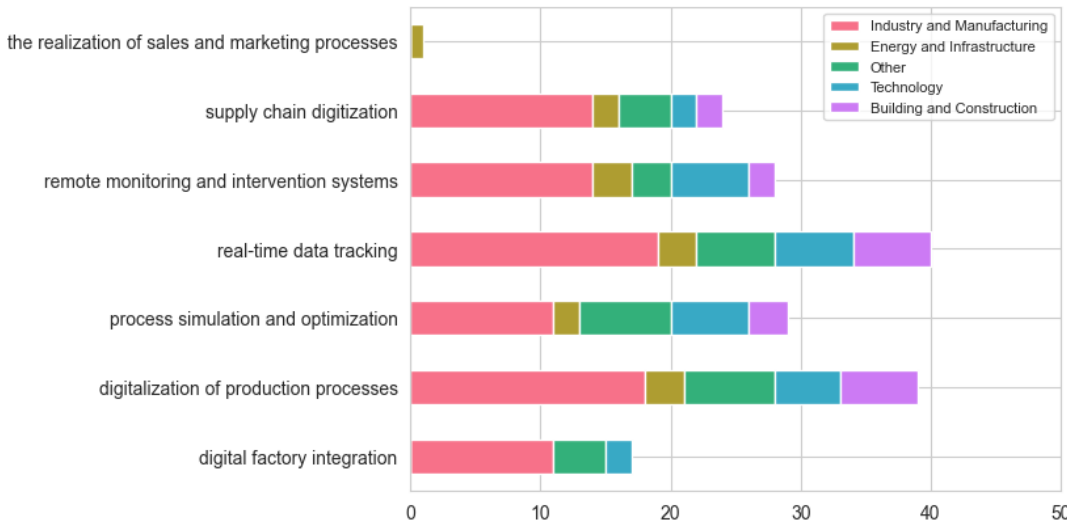

Figure 4-14: Demand for training sub-topics (according to sector)

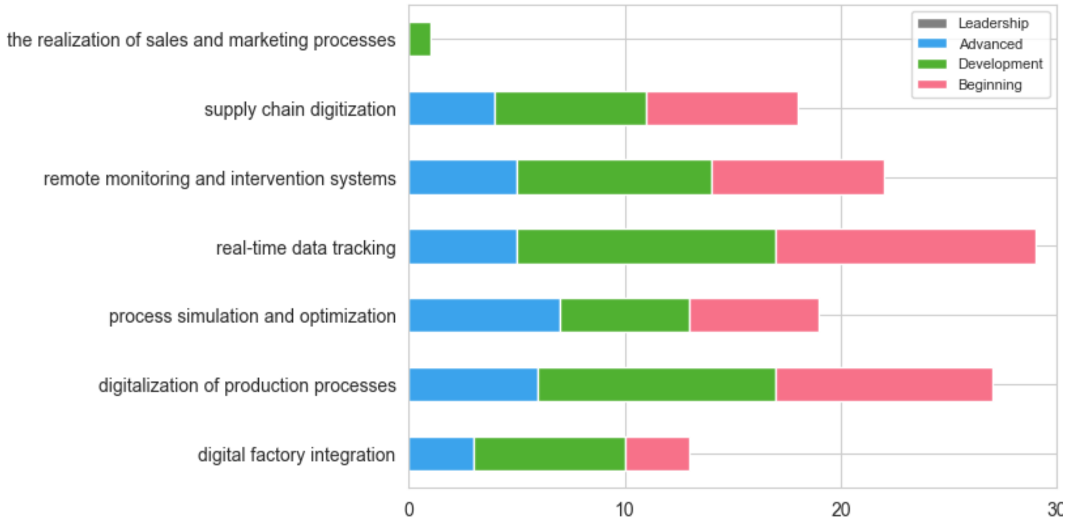

Figure 4-15: Demand for training sub-topics (according to perceived digital maturity level)

4.2 Artificial Intelligence

The survey results show that the adoption of artificial intelligence among SMEs remains limited, with most firms still in early awareness or exploratory stages. Companies express high training demand in core AI areas such as machine learning, deep learning, and computer vision. Application-oriented topics—particularly predictive maintenance, quality control, and generative AI (e.g., chatbots)—emerge as top priorities. Training needs differ by company size and sector, but the overall trend highlights a strong preference for practical, use-case-driven learning formats that bridge the gap between theoretical knowledge and industrial implementation.

4.2.1 Current State and Maturity for Artificial intelligence

Figures 4.16 to 4.24 explore AI adoption purposes, digital competencies, and training methods segmented by sector, size, and digital maturity. AI is mainly used in predictive analytics and quality control (Figs. 4.16, 4.19, 4.22). Most employees (Figs. 4.17, 4.20, 4.23) are either unaware of AI or possess only basic knowledge. Upskilling efforts are dominated by peer-led initiatives or self-learning platforms (Figs. 4.18, 4.21, 4.24). Firms with higher digital maturity demonstrate greater adoption of AI for strategic purposes and invest more in AI-related training.

Manufacturing SMEs remain in the early stages of AI awareness, mostly lacking the expertise to integrate AI into core operations. However, those exploring AI tend to focus on high-impact areas like predictive maintenance and visual quality inspection. These results point to the need for beginner-to-intermediate AI training pathways targeting production engineers and IT staff, focusing on use-case-driven modules with industrial data examples.

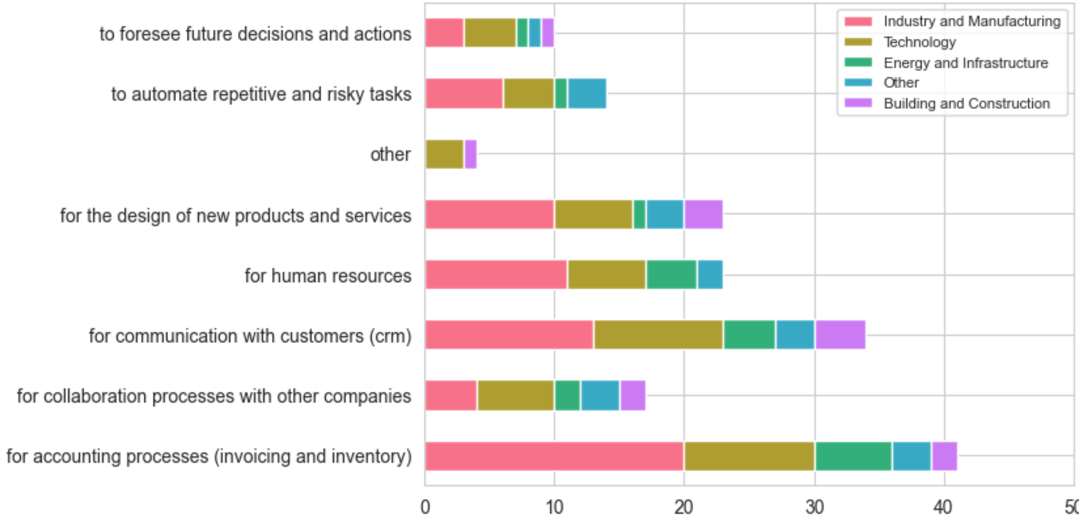

Figure 4-16: Purpose of using digital technologies – AI (according to sector)

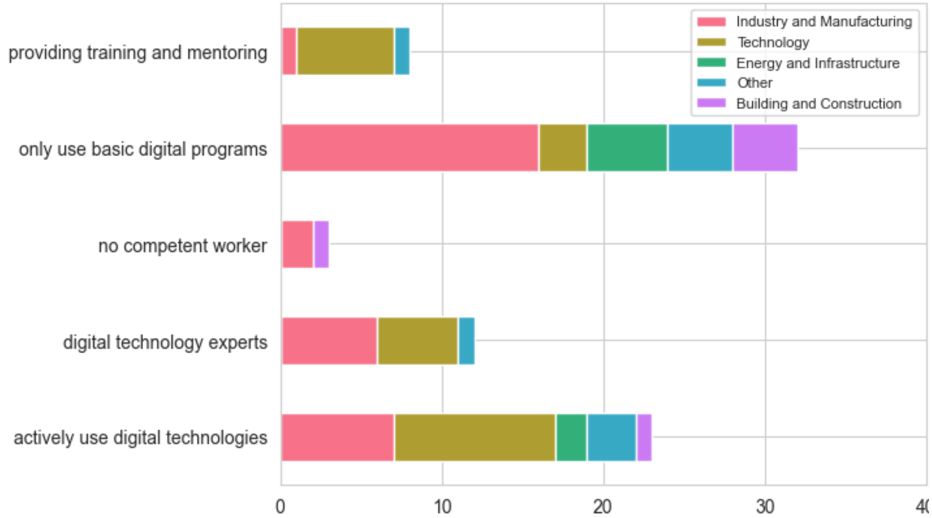

Figure 4-17: Digital competency level of employees – AI (according to perceived digital maturity level)

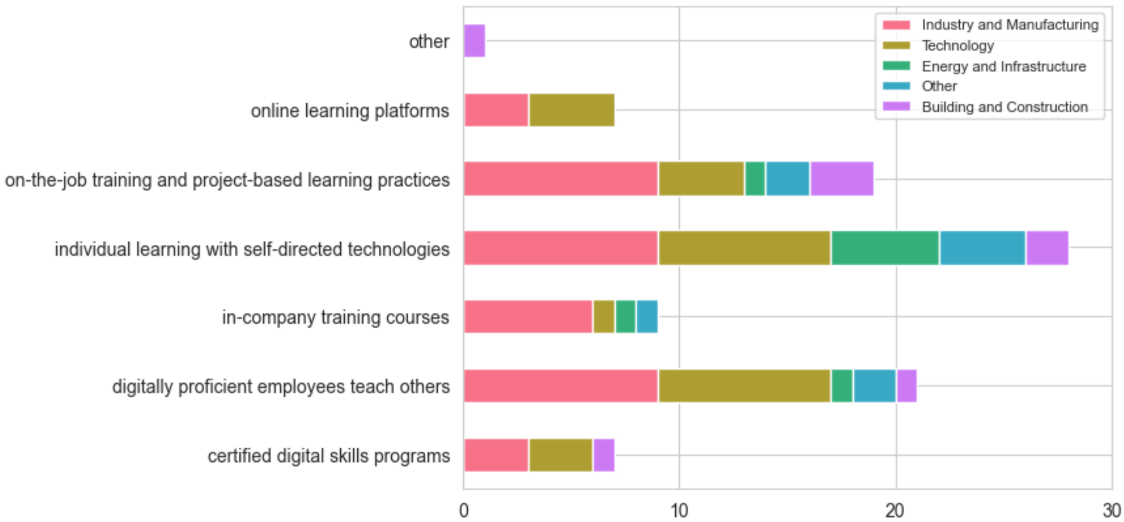

Figure 4-18: Methods to improve the digital skills of employees – AI (according to perceived digital maturity level)

Figure 4-19: Purpose of using digital technologies – AI (according to size)

Figure 4-20: Digital competency level of employees – AI (according to size)

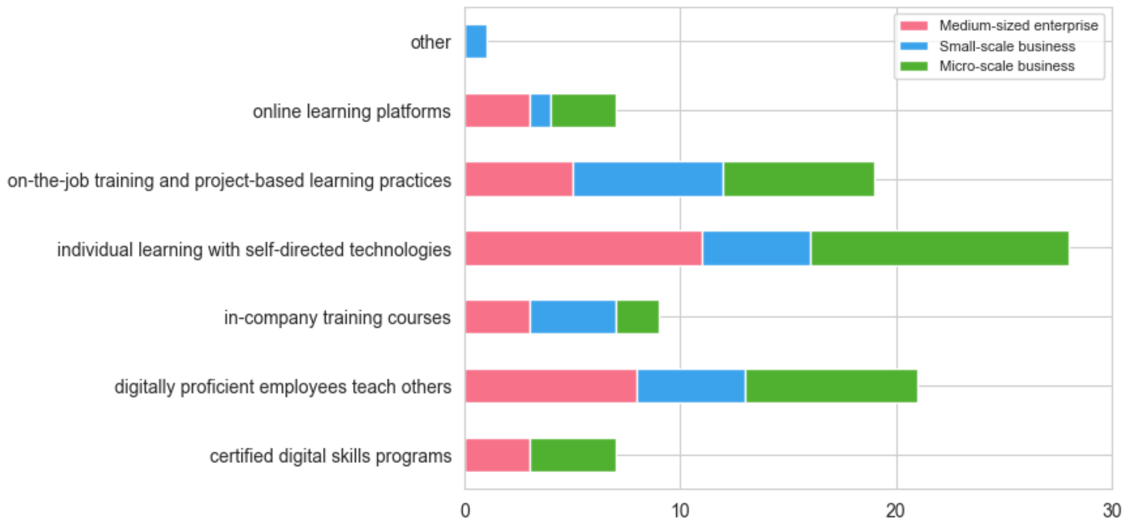

Figure 4-21: Methods to improve the digital skills of employees – AI (according to size)

Figure 4-22: Purpose of using digital technologies – AI (according to perceived digital maturity level)

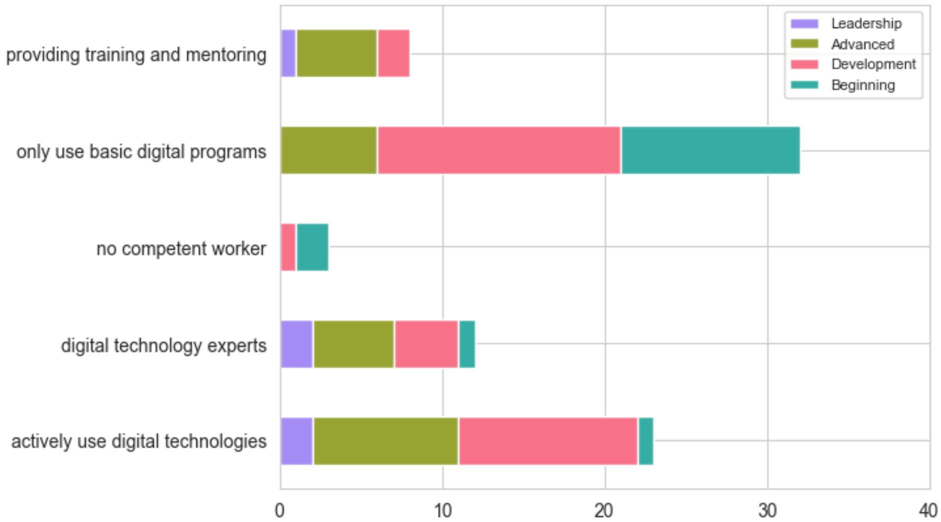

Figure 4-23: Digital competency level of employees – AI

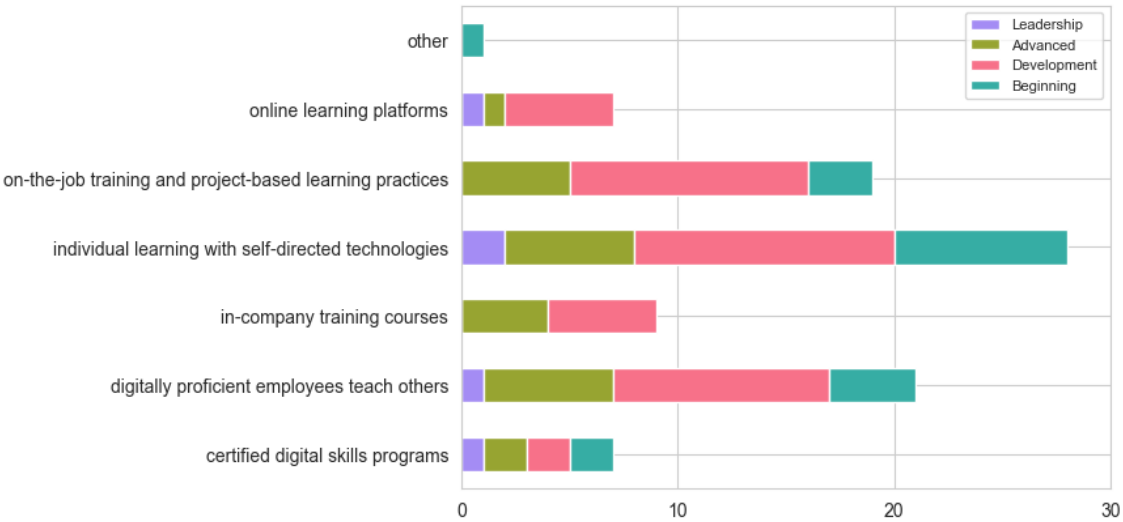

Figure 4-24: Methods to improve the digital skills of employees – AI (according to perceived digital maturity level)

4.2.2 Training Needs for Artificial Intelligence

Figures 4.25 to 4.30 identify strong demand in core AI domains such as machine learning, deep learning, and computer vision. Figures 4.26, 4.28, 4.29, and 4.30 reveal that specific application areas—like predictive maintenance, quality control, and generative AI—are prioritized. Digitally mature firms and larger enterprises demonstrate broader interest in NLP and robotics, reflecting greater strategic capacity.

For manufacturing SMEs, the most relevant sub-topics are those that directly enhance product quality and reduce downtime. Computer vision systems for inspection and predictive algorithms for machine maintenance are seen as feasible AI applications. Training should therefore emphasize applied ML/DL with industrial datasets, and offer plug-and-play toolkits to support rapid prototyping.

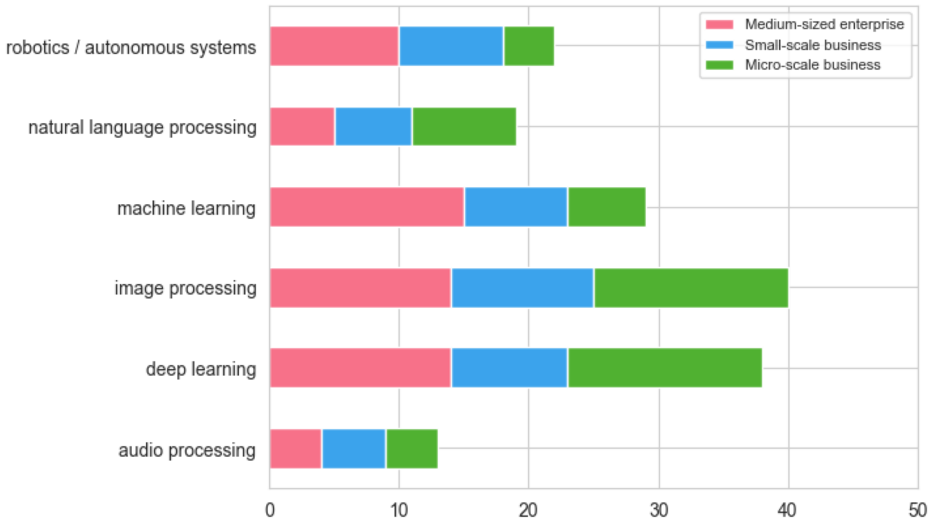

Figure 4-25: Demand for training topics – AI (according to size)

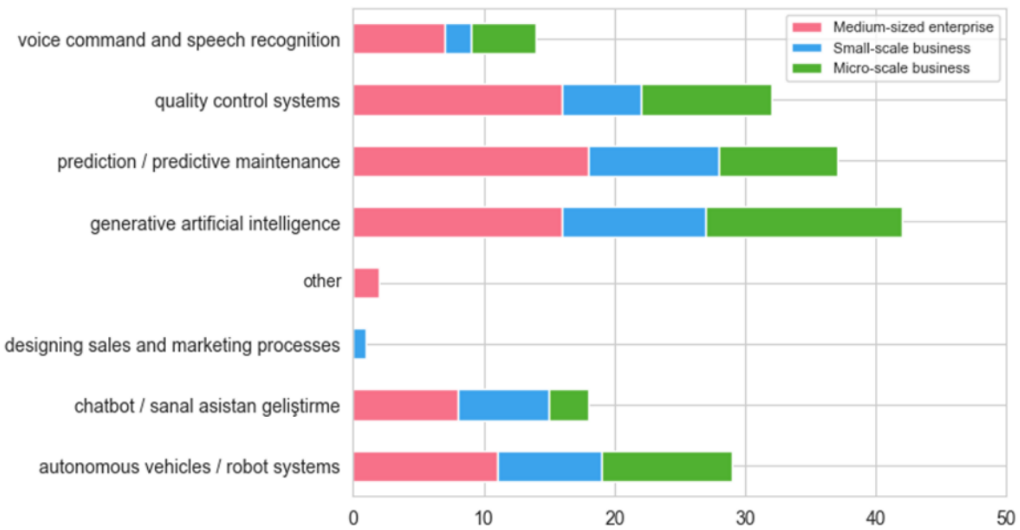

Figure 4-26: Demand for training sub-topics – AI (according to size)

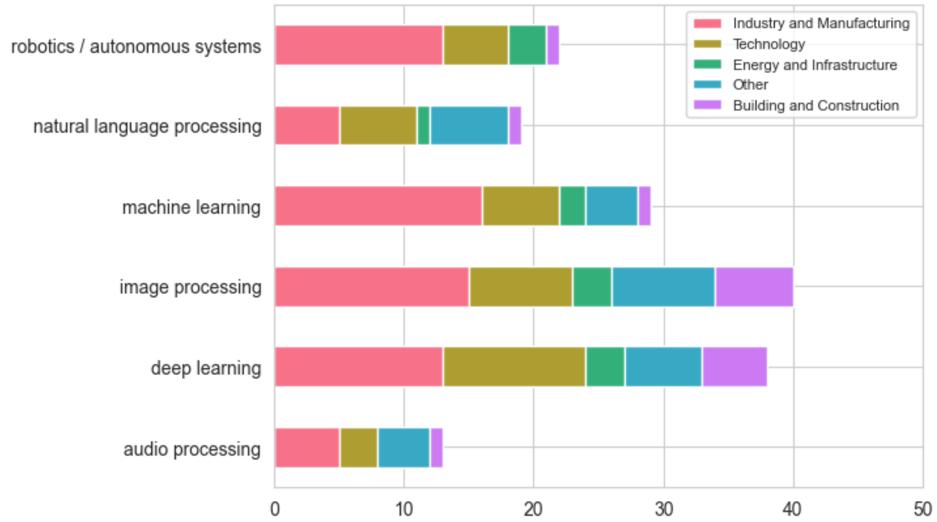

Figure 4-27: Demand for training topics – AI (according to sector)

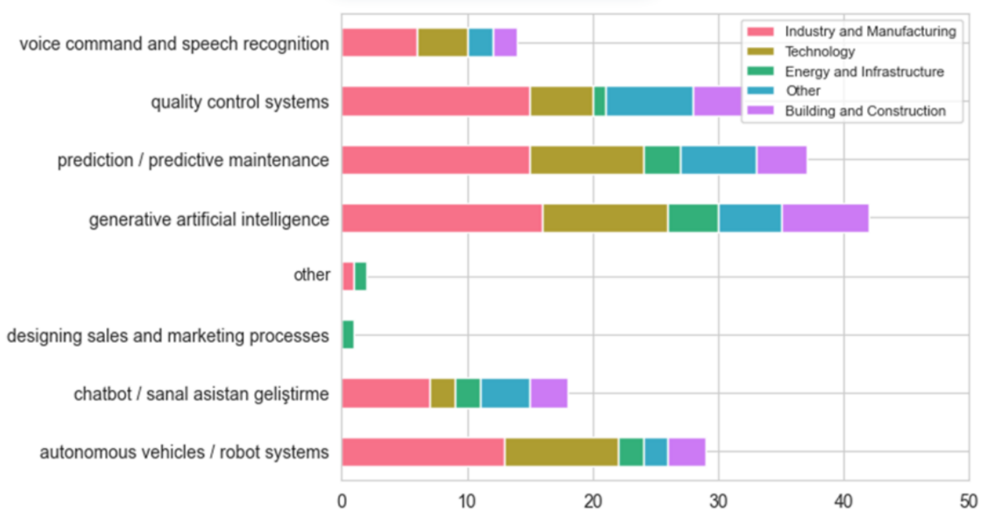

Figure 4-28: Demand for training sub-topics – AI (according to sector)

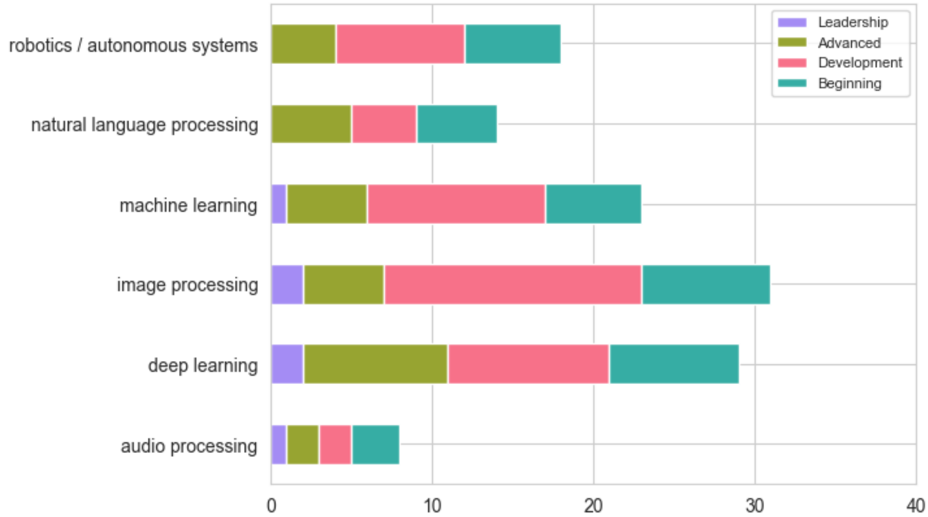

Figure 4-29: Demand for training sub-topics – AI (according to perceived digital maturity level)

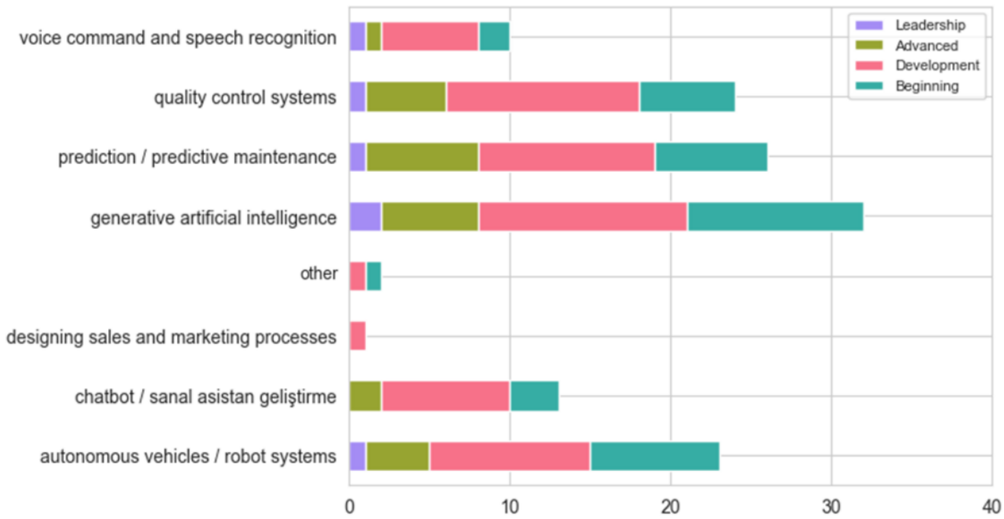

Figure 4-30: Demand for training sub-topics – AI (according to perceived digital maturity level)

4.3 Data Science

The survey results show that data science adoption is at an emerging stage among SMEs, with limited institutional capacity for advanced analytics. Training needs are concentrated around data analysis and visualization, predictive modeling, and Python-based data handling. Key application areas include operational decision-making, production data analysis, anomaly detection, and predictive maintenance. While technical staff are the primary target group, firms also recognize the value of developing data literacy across broader roles. The findings underscore a strong demand for hands-on, tool-based training that links data science methods directly to production and business operations.

4.3.1 Current State and Maturity for Data Science

Figures 4.31 to 4.39 show that data science is used mostly for operational decision-making and anomaly detection. Figures 4.32, 4.35, and 4.38 highlight the low skill level in data analytics across all firm sizes. Training efforts rely heavily on self-paced and internal learning (Figs. 4.33, 4.36, 4.39). Larger and more mature firms display more diversified data applications and competencies.

Data science adoption among manufacturing SMEs is still in its infancy. Their limited capabilities restrict them to basic applications, preventing full exploitation of production data. Targeted training in Python-based data wrangling, visual analytics, and anomaly detection could help SMEs translate raw sensor data into actionable insights. Cross-functional training that includes non-technical staff will also help foster a data-aware culture.

Figure 4-31: Purpose of using digital technologies – Data Science (according to sector)

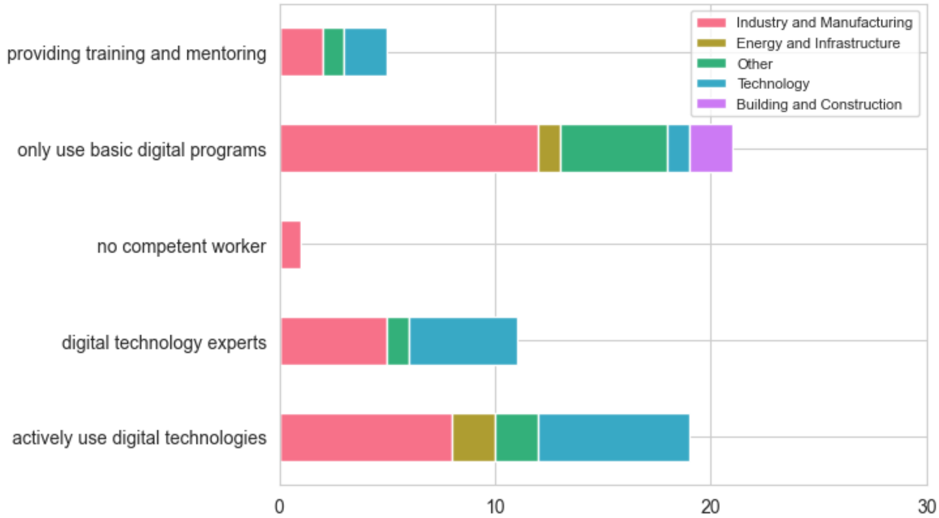

Figure 4-32: Digital competency level of employees – Data Science (according to sector)

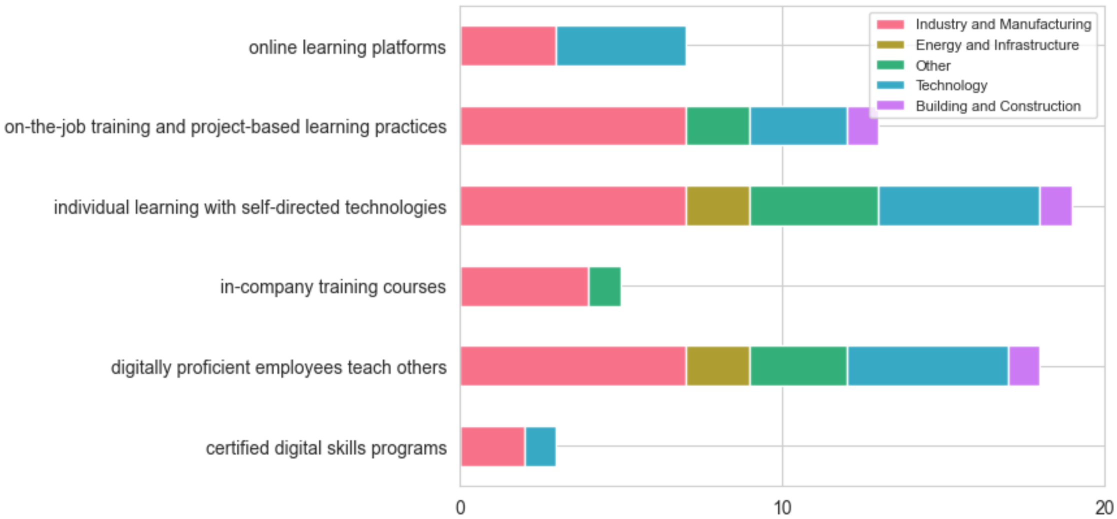

Figure 4-33: Methods to improve the digital skills of employees – Data Science (according to sector)

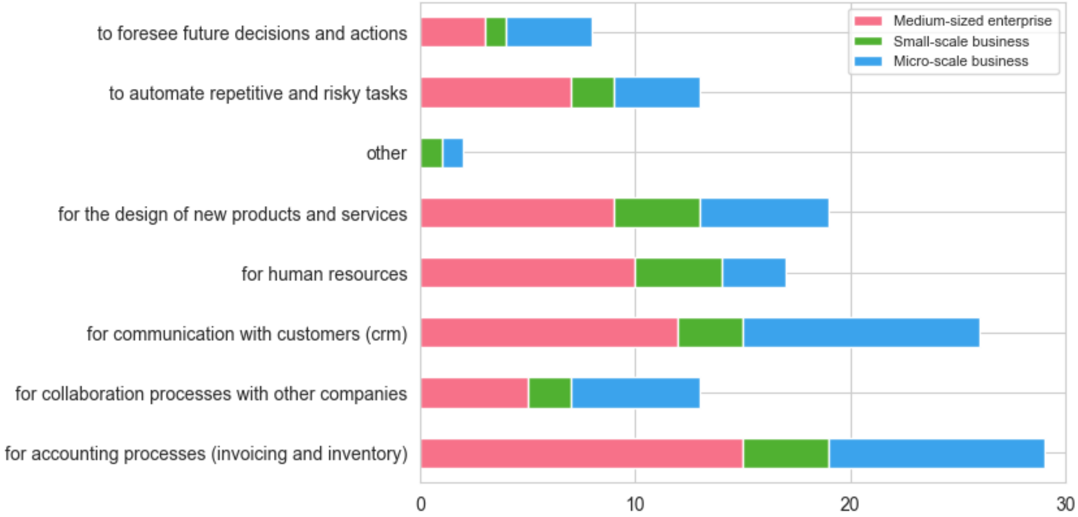

Figure 4-34: Purpose of using digital technologies – Data Science (according to size)

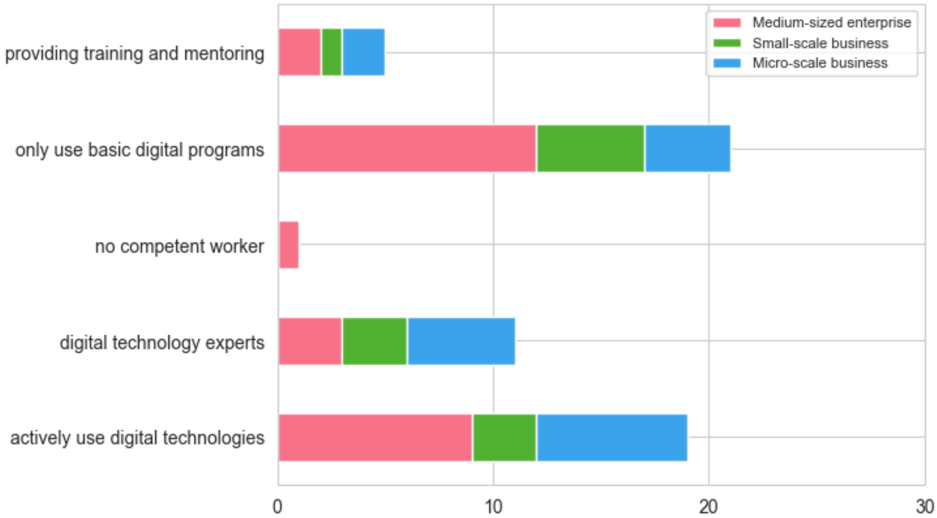

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Figure 4-35: Digital competency level of employees – Data Science (according to size)

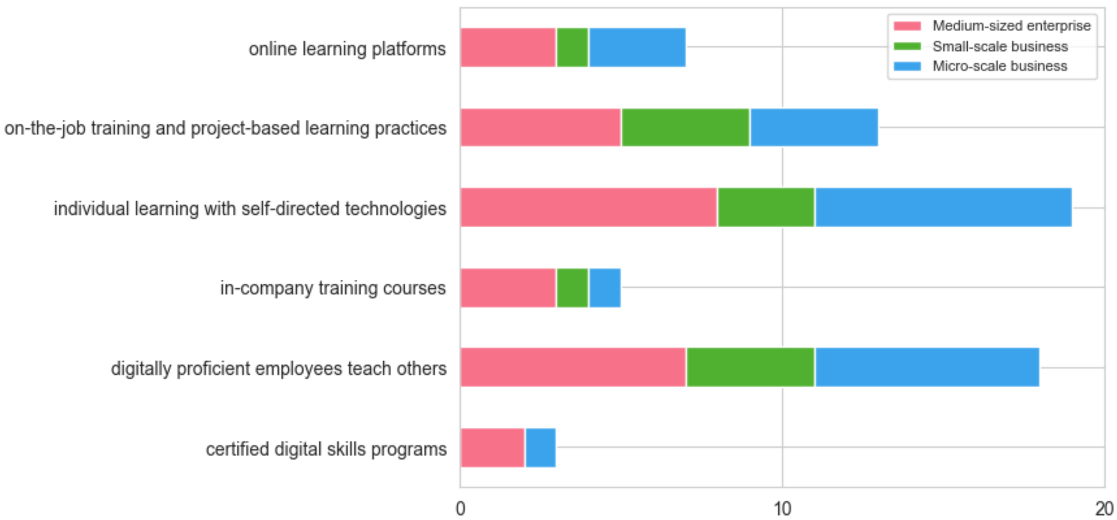

Figure 4-36: Methods to improve the digital skills of employees – Data Science (according to size)

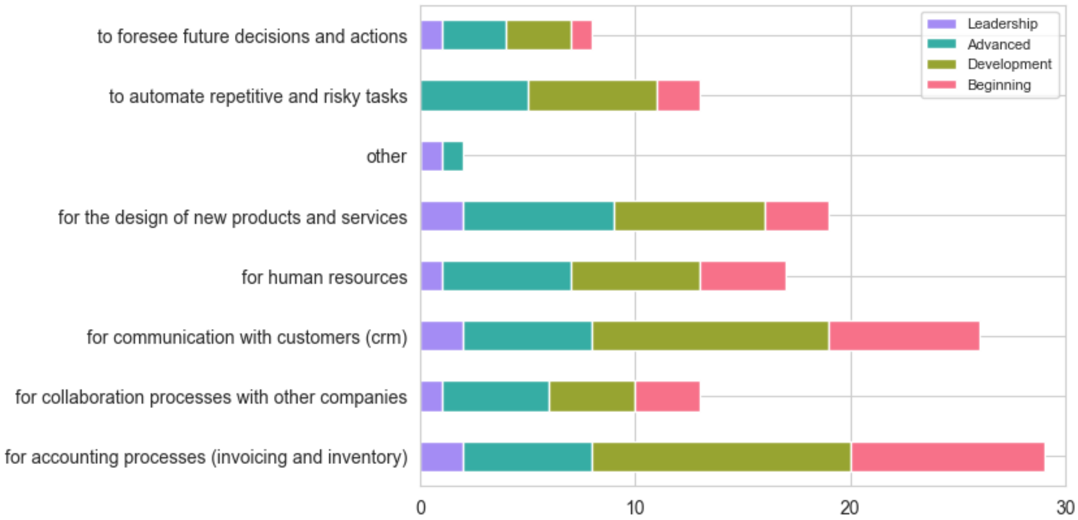

Figure 4-37: Purpose of using digital technologies – Data Science (according to perceived digital maturity level)

Figure 4-38: Digital competency level of employees – Data Science (according to perceived digital maturity level)

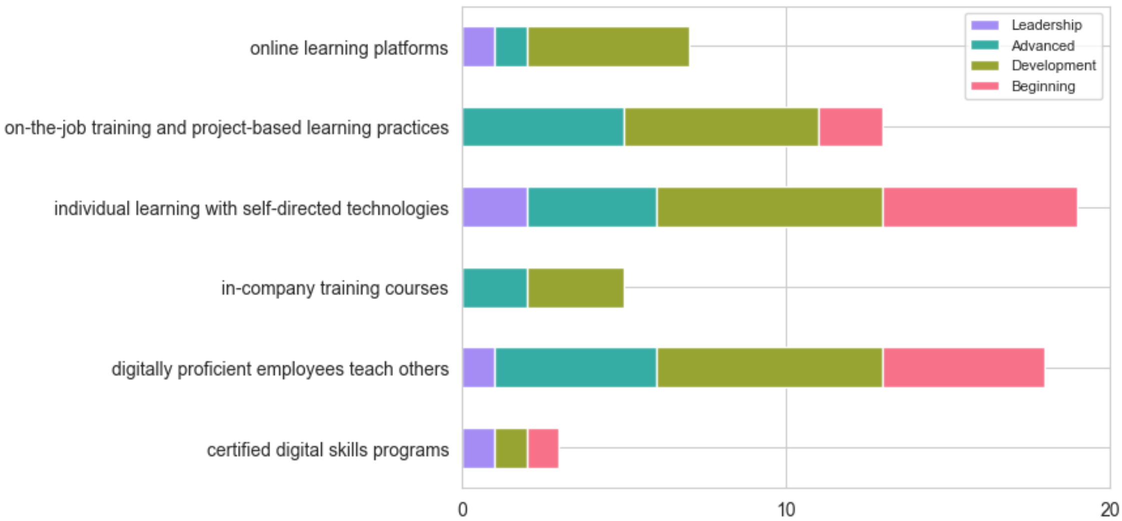

Figure 4-39: Methods to improve the digital skills of employees – Data Science (according to perceived digital maturity level)

4.3.2 Training Needs for Data Science

Figures 4.40 to 4.45 point to high interest in predictive modeling, data visualization, and Python scripting. Training sub-topic preferences include production data analysis, business intelligence, and forecasting. More advanced firms also look for training in big data management and decision support systems.

Manufacturing SMEs benefit most from training that bridges data science techniques with shop floor realities. The top-priority areas—like production analytics and forecasting—can directly improve throughput and inventory control. Short-term, task-based modules teaching Pandas, Matplotlib, and real-time dashboards can offer tangible value with minimal disruption.

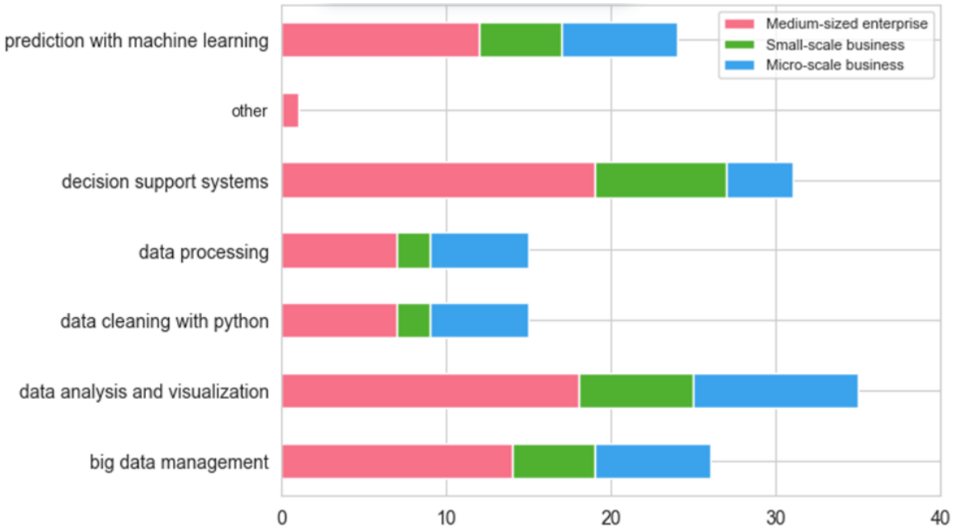

Figure 4-40: Demand for training topics – Data Science (according to size)

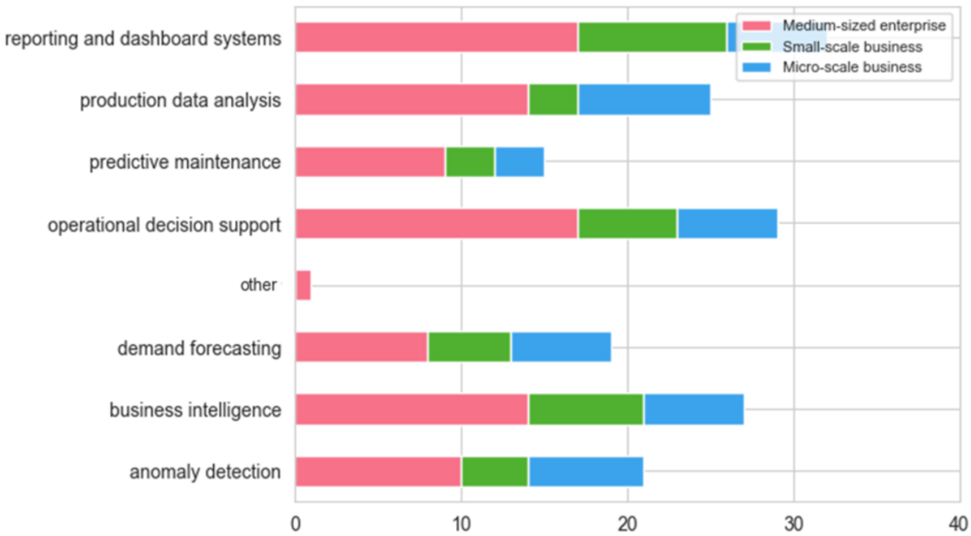

Figure 4-41: Demand for training sub-topics – Data Science (according to size)

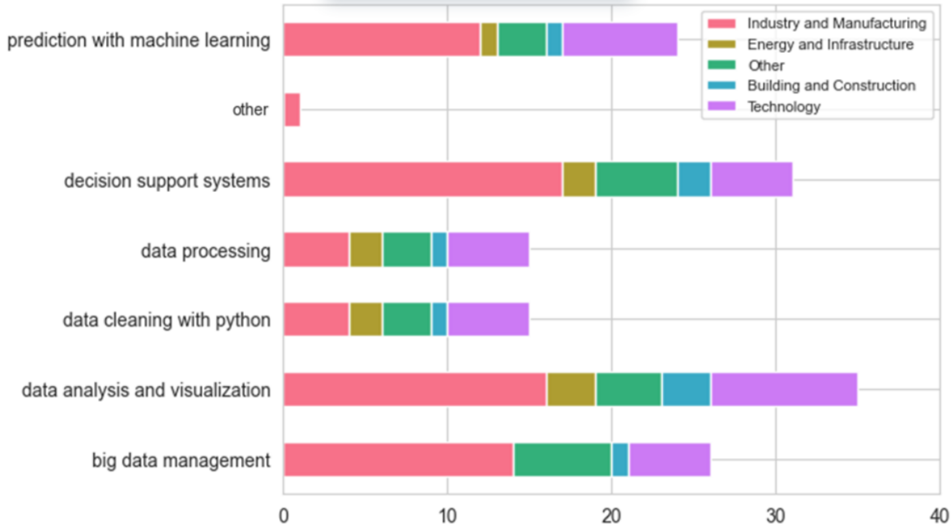

Figure 4-42: Demand for training topics – Data Science (according to sector)

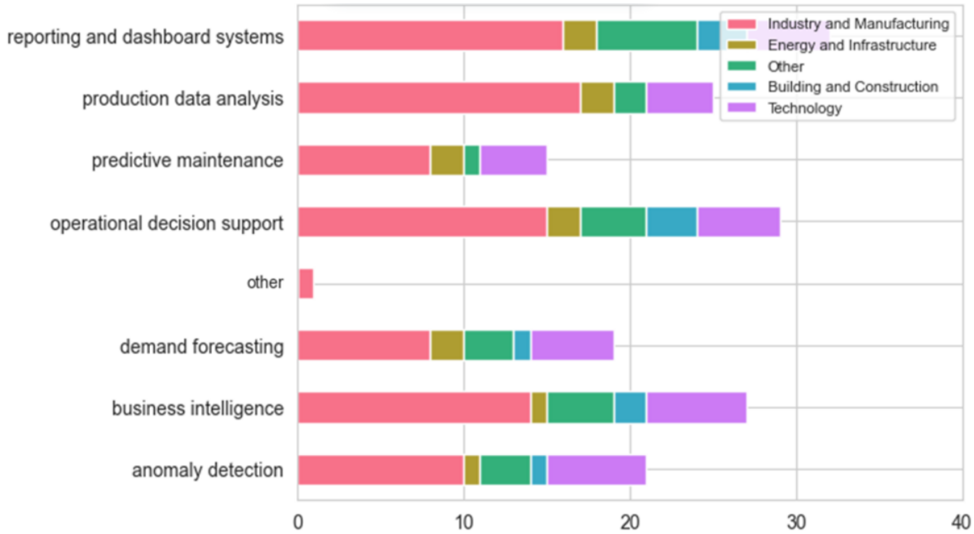

Figure 4-43: Demand for training sub-topics – Data Science (according to sector)

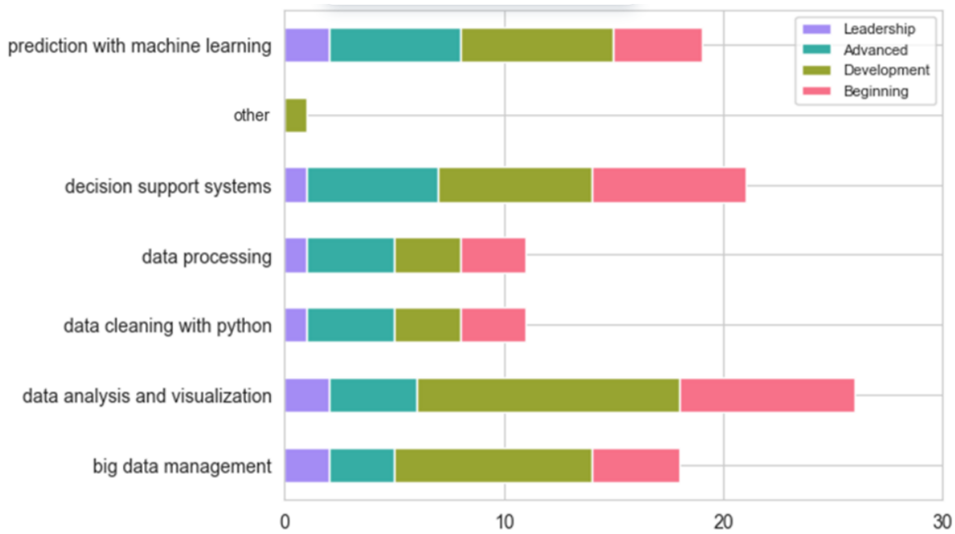

Figure 4-44: Demand for training topics – Data Science (according to perceived digital maturity level)

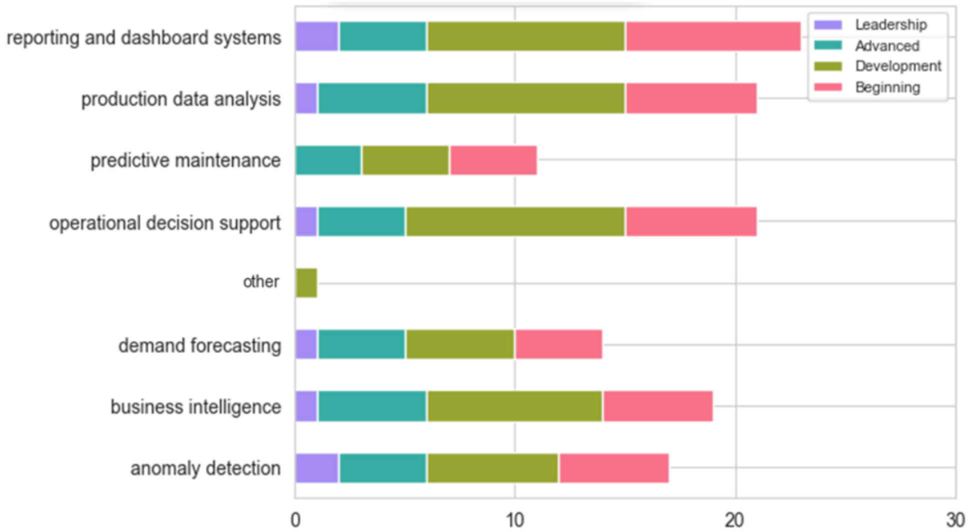

Figure 4-45: Demand for training sub-topics – Data Science (according to perceived digital maturity level)

4.4 Sustainability

The survey results show that sustainability practices are gaining attention among SMEs, yet implementation remains uneven. The most pressing training needs are in carbon footprint calculation, ESG reporting, circular economy, and sustainable supply chain management. Firms show strong interest in application areas such as green production, energy efficiency monitoring, and sustainable finance. While larger firms are slightly more advanced, SMEs across all sectors express a desire for practical, sector-specific training that aligns with regulatory expectations and international sustainability trends. The results highlight the need to embed sustainability into digital transformation efforts through integrated, actionable learning modules.

4.4.1 Current State and Maturity for Sustainability

Figures 4.46 to 4.54 illustrate how companies use digital tools for sustainability, employee competence levels, and training methods. Energy monitoring and green production are among the most cited purposes. Competencies in sustainability remain underdeveloped, and most upskilling takes place through informal or internal means. Larger and more digitally mature firms lead in integrating sustainability into operations.

Sustainability efforts in manufacturing SMEs are often limited by resource constraints and lack of expertise. However, interest in reducing energy usage and complying with ESG standards is growing. Entry-level training should focus on carbon footprint basics, energy audits, and practical metrics. Sector-specific tools for sustainable production and digital traceability should also be introduced.

Figure 4-46: Purpose of using digital technologies – Sustainability (according to sector)

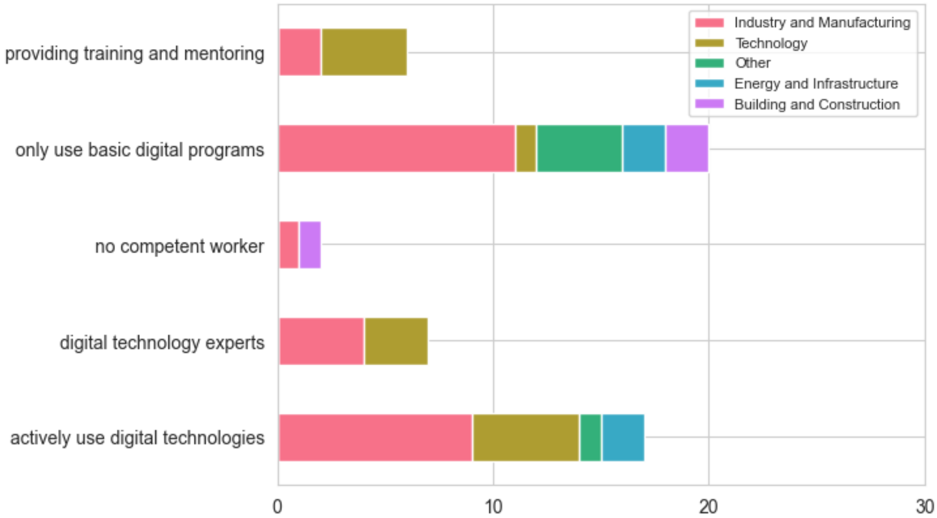

Figure 4-47: Digital competency level of employees – Sustainability (according to sector)

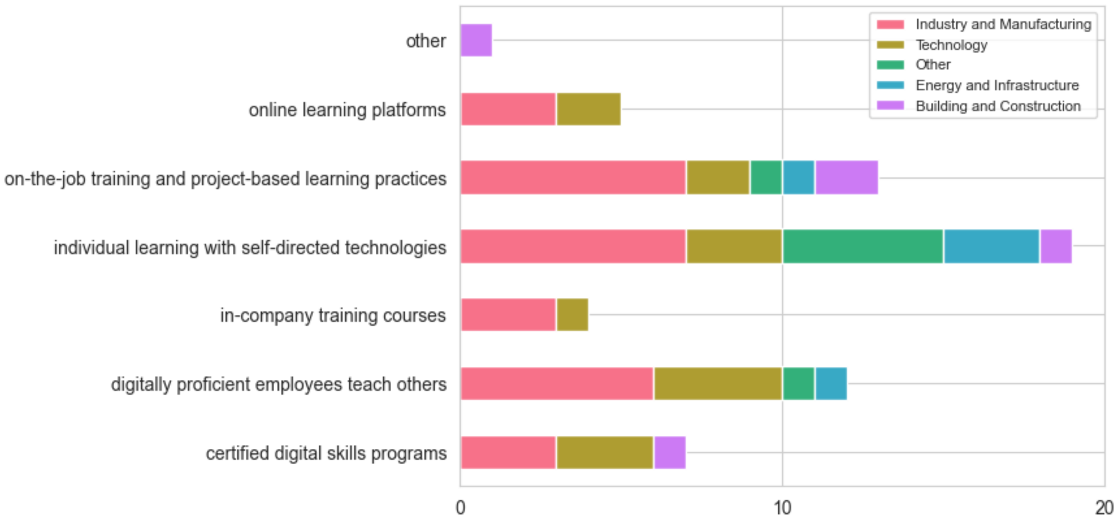

Figure 4-48: Methods to improve the digital skills of employees – Sustainability (according to sector)

Figure 4-49: Purpose of using digital technologies – Sustainability (according to sector)

Figure 4-50: Digital competency level of employees – Sustainability (according to size)

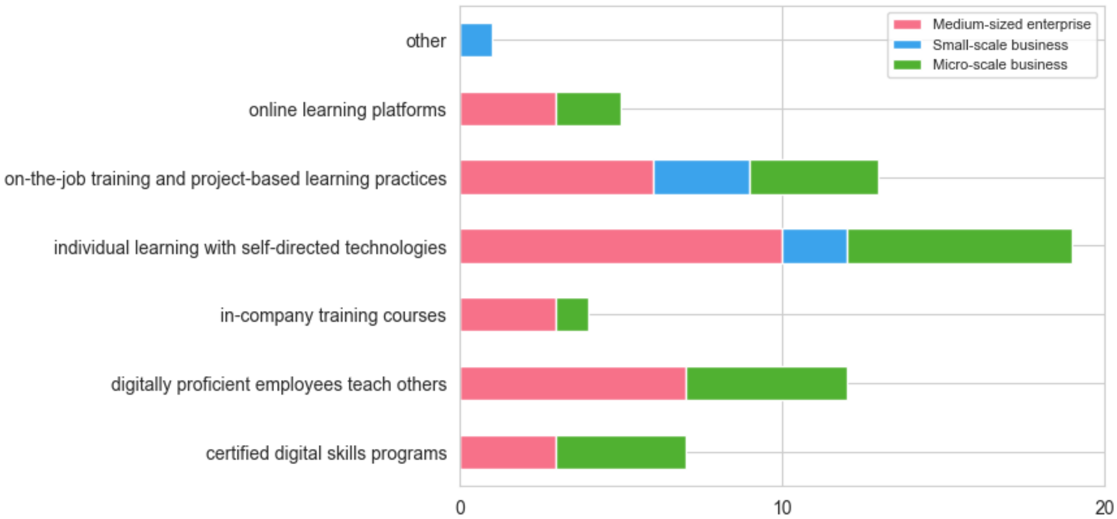

Figure 4-51: Methods to improve the digital skills of employees – Sustainability (according to size)

Figure 4-52: Purpose of using digital technologies – Sustainability (according to perceived digital maturity level)

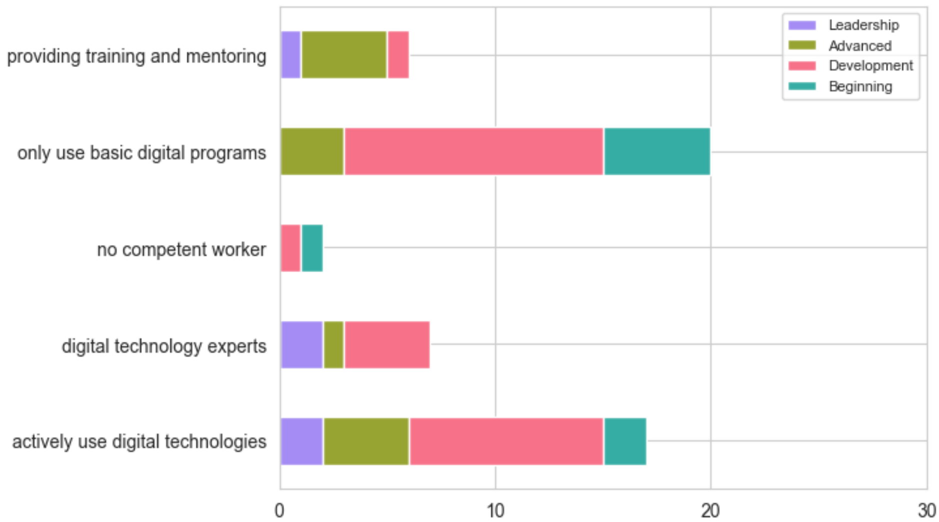

Figure 4-53: Digital competency level of employees – Sustainability (according to perceived digital maturity level)

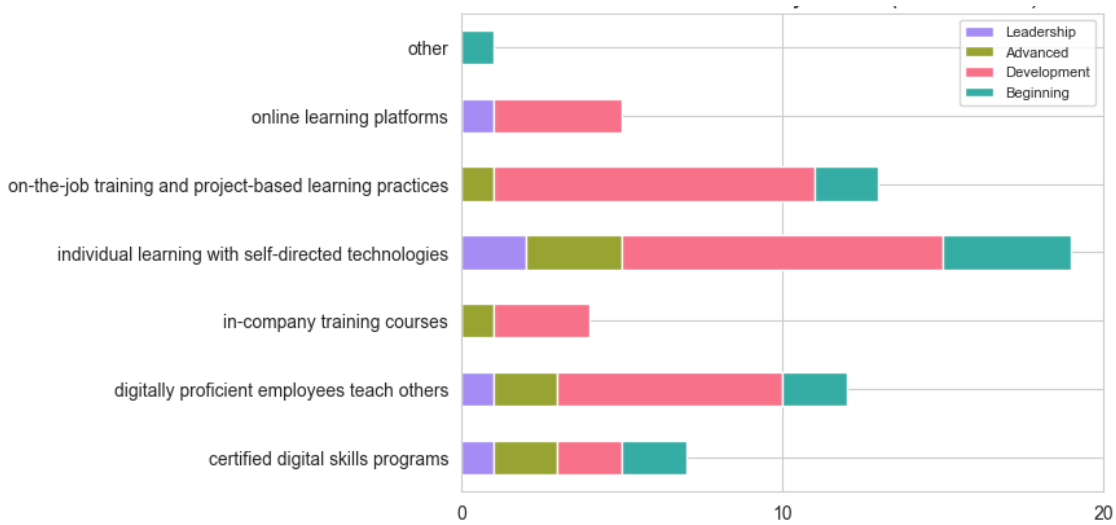

Figure 4-54: Methods to improve the digital skills of employees – Sustainability (according to perceived digital maturity level)

4.4.2 Training Needs for Sustainability

Figures 4.55 to 4.60 show consistent training needs in ESG reporting, carbon accounting, and circular economy principles. Energy efficiency and sustainable supply chain management are emphasized across all firm types. Digital maturity enhances the breadth and depth of sustainability training demand.

Manufacturing SMEs are especially motivated to align with EU Green Deal directives and customer expectations. Training should therefore include LCA tools, ESG metrics, and strategies for resource-efficient production. Modules should be low-cost, practical, and relevant to their specific value chains, offering both compliance support and competitive advantage.

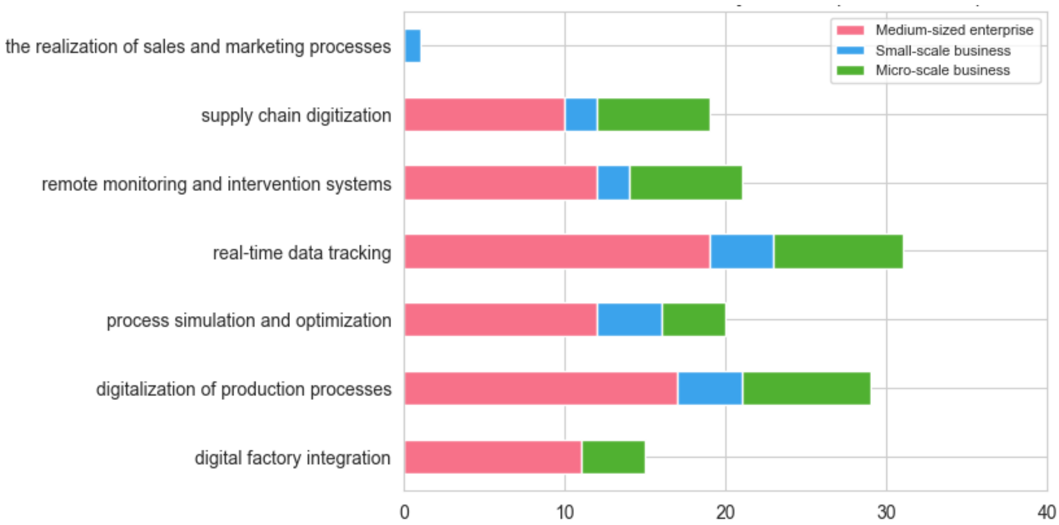

Figure 4-55: Demand for training topics – Sustainability (according to size)

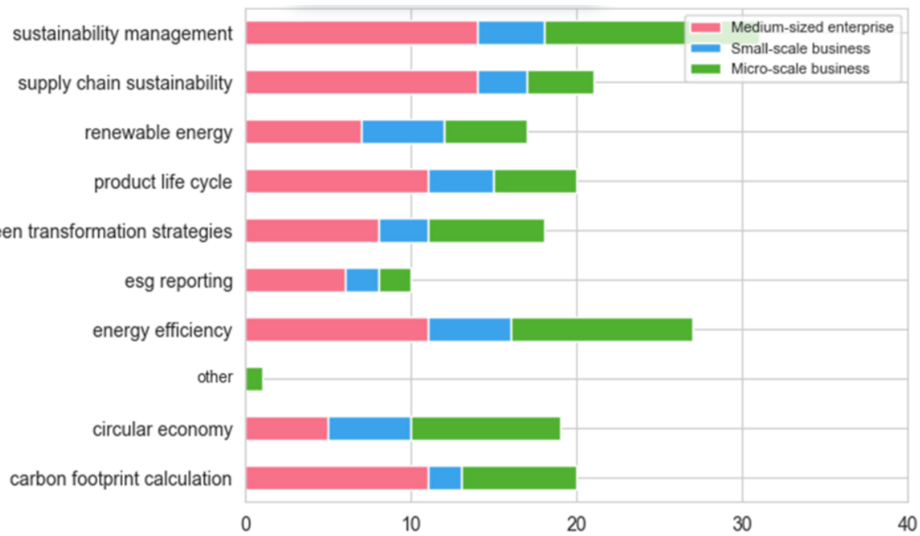

Figure 4-56: Demand for training sub-topics – Sustainability (according to size)

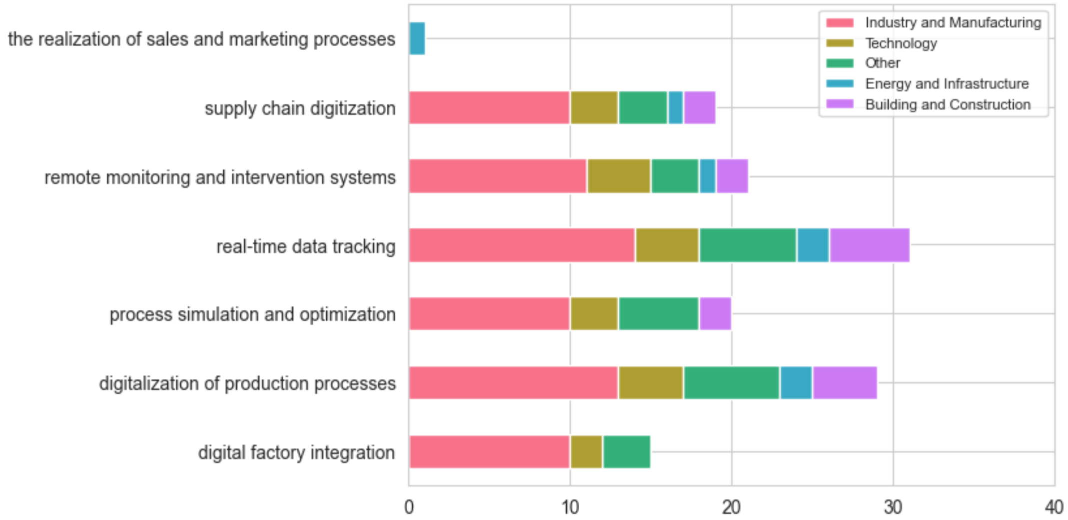

Figure 4-57: Demand for training topics – Sustainability (according to sector)

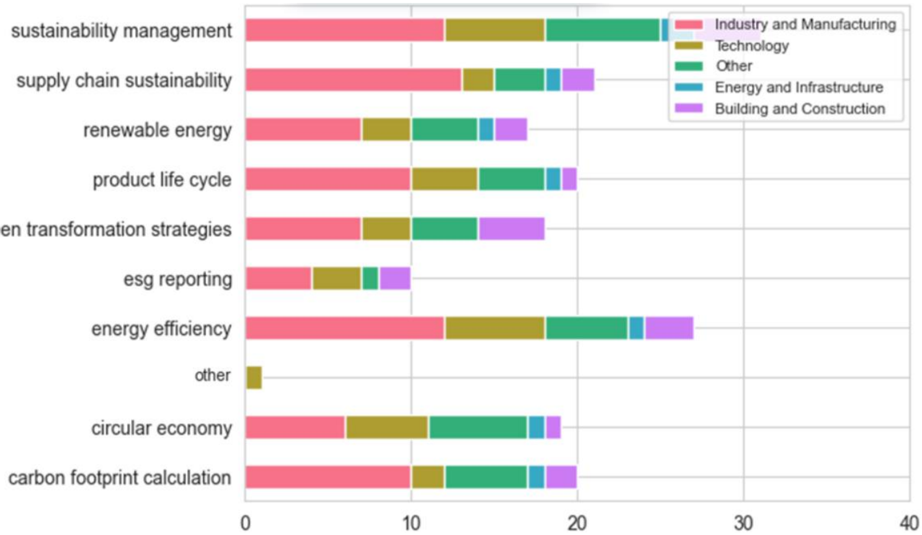

Figure 4-58: Demand for training sub-topics – Sustainability (according to sector)

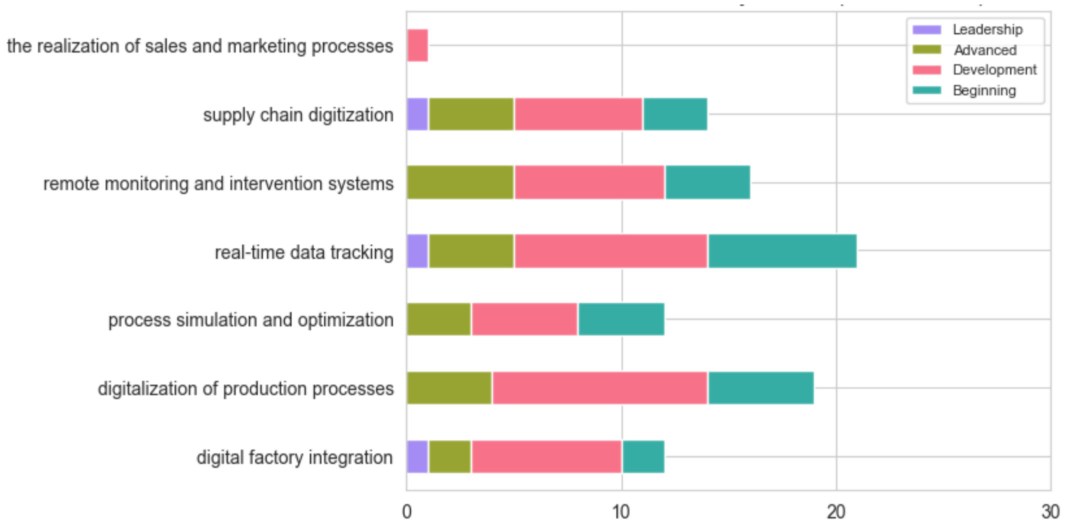

Figure 4-59: Demand for training topics – Sustainability (according to perceived digital maturity level)

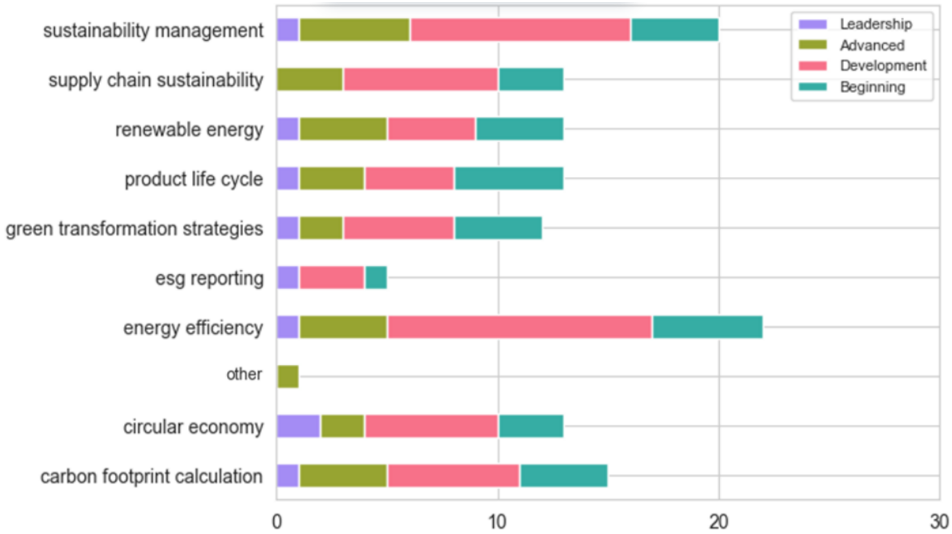

Figure 4-60: Demand for training sub-topics – Sustainability (according to perceived digital maturity level)

4.5 Preferred Training Formats

The survey results show that SMEs overwhelmingly prefer training formats that are practical, flexible, and time efficient. Hands-on training, on-site workshops, and blended learning (combining online and in-person sessions) are the most favored approaches. These preferences reflect the operational constraints of SMEs and underline the importance of delivering applied content in formats that minimize disruption to daily business activities. *Figures 4.61* and *4.62* reveal that hands-on training, on-site workshops, and blended learning are the preferred formats. These methods are favored because they provide flexibility and minimize disruption to operations. In-person learning remains valuable, especially in sectors like manufacturing.

Manufacturing SMEs require training that is directly applicable to the shop floor. On-site workshops enable contextual learning using actual machinery and processes. Blended formats that include recorded demos and live Q&A sessions are ideal for teams with shift work constraints. Programs should offer certifications to enhance motivation.

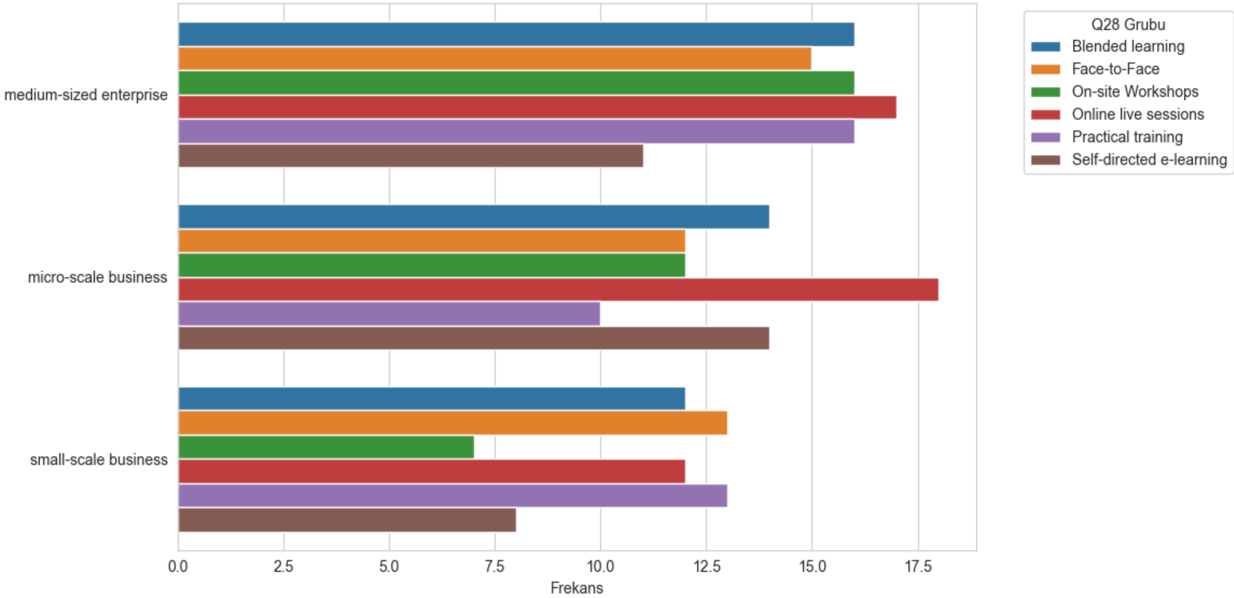

Figure 4-61: Preferred training formats according to size of the enterprise

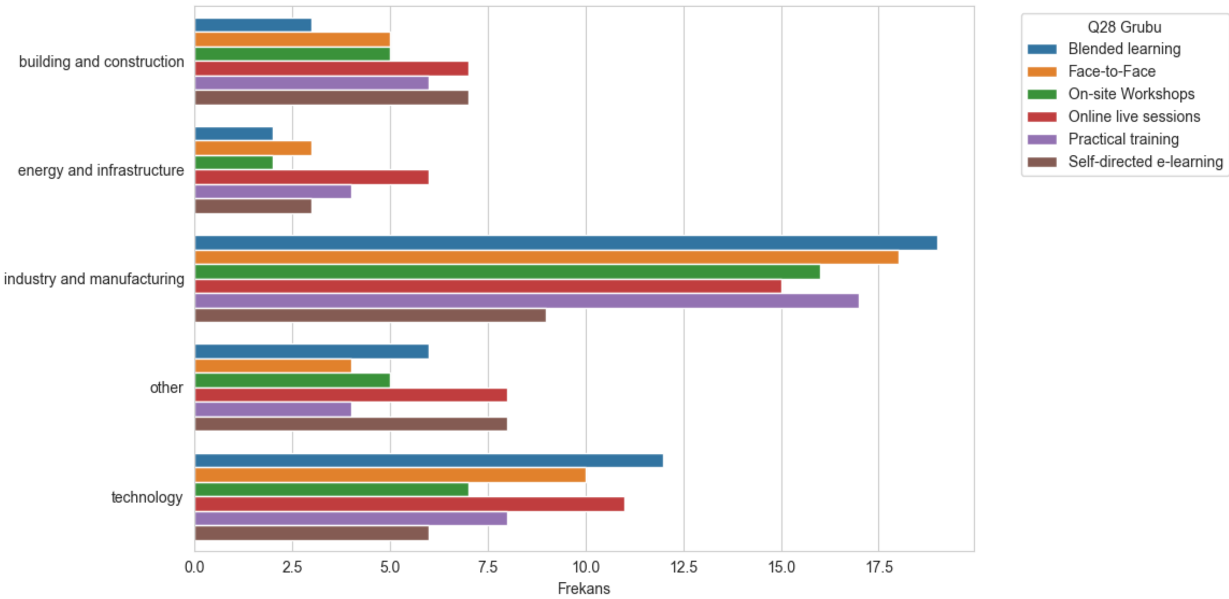

Figure 4-62: Preferred training formats according to sector

4.6 Preferred Training Times

The survey results show that SMEs show a clear preference for short and concentrated training schedules that align with their operational realities. Short-duration formats such as 1–2-hour webinars, half-day sessions, and intensive weekend programs are preferred over long-term academic-style courses. Multi-day program" and "Short web seminar" appear to be generally popular across many categories, while "After work" training consistently shows lower preference in both figures. This indicates a strong demand for flexibility, allowing employees to engage in training without interrupting core business operations. The findings suggest that timing is as critical as content in ensuring participation and impact of upskilling initiatives. *Figures 4.63* and *4.64* indicate a preference for short formats such as 1–2-hour webinars, half-day workshops, and multi-day intensives. "After work" and full-weekend sessions are less favored. This reflects the need to align with business operations and reduce workforce disruption.

For manufacturing SMEs, the best training schedule is one that minimizes production downtime. Short, modular sessions allow staggered participation across shifts. Intensive formats over 1–2 consecutive days may also work if aligned with maintenance periods or off-peak production cycles. Offering recorded versions helps improve accessibility and inclusivity.

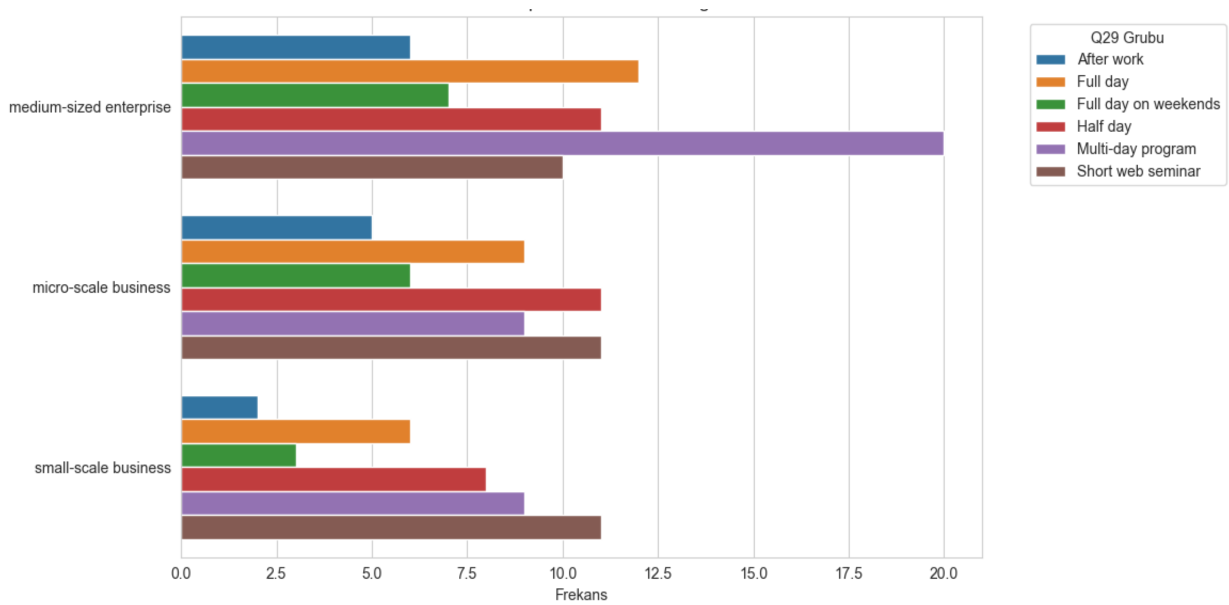

Figure 4-63: Preferred training times according to size

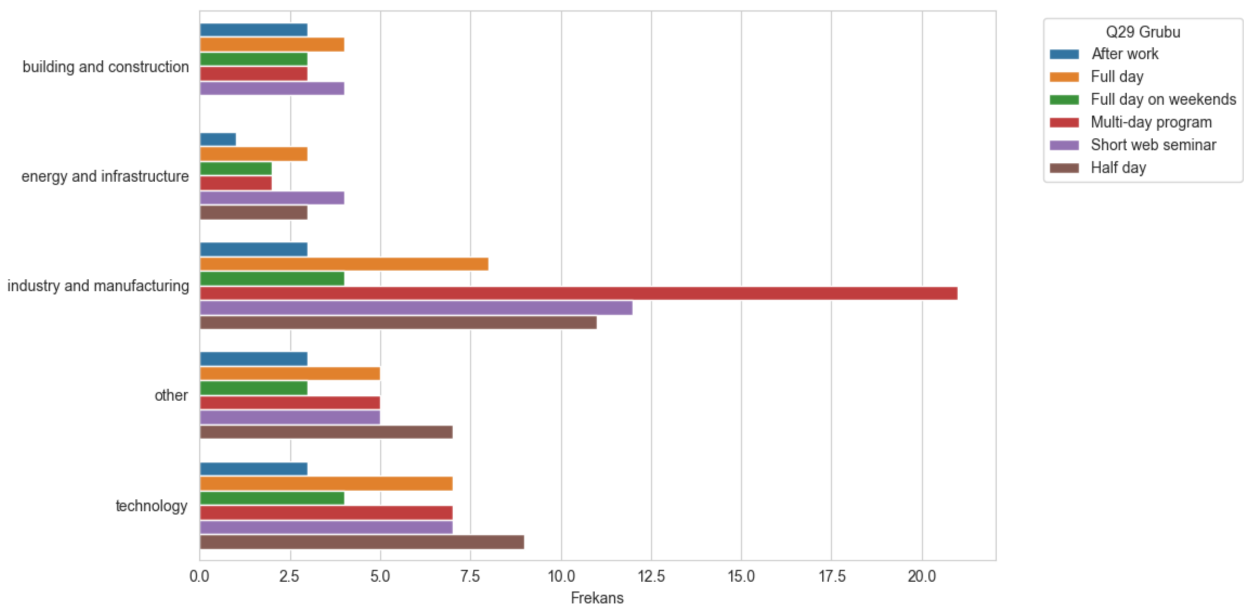

Figure 4-64: Preferred training times according to sector

4.7 Comparison of SMEs and LEs

While the sample size is relatively small to arrive at general conclusions based on interpretative statistical analyses, available data gives insights into the differences between SMEs and LEs in digital maturity, training needs, and capacity-building practices. LEs report higher digital competency levels and broader use of advanced technologies, particularly in AI and data science. They are more likely to have structured in-house training programs and utilize certified or platform-based learning. SMEs, on the other hand, exhibit greater variability in digital readiness and rely more heavily on peer learning or informal training methods. Both groups prioritize hands-on, application-driven training formats; however, SMEs place relatively higher emphasis on operational use cases and shorter, modular formats. These distinctions underscore the importance of segmenting training programs by firm size to ensure alignment with organizational capabilities and resource constraints.

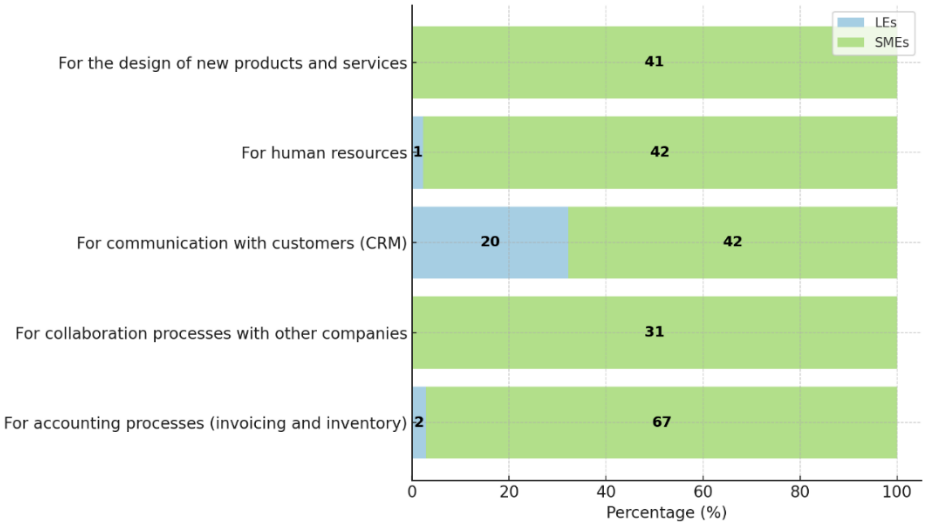

Figure 4-65: Purpose of using digital technologies (SMEs vs LEs)

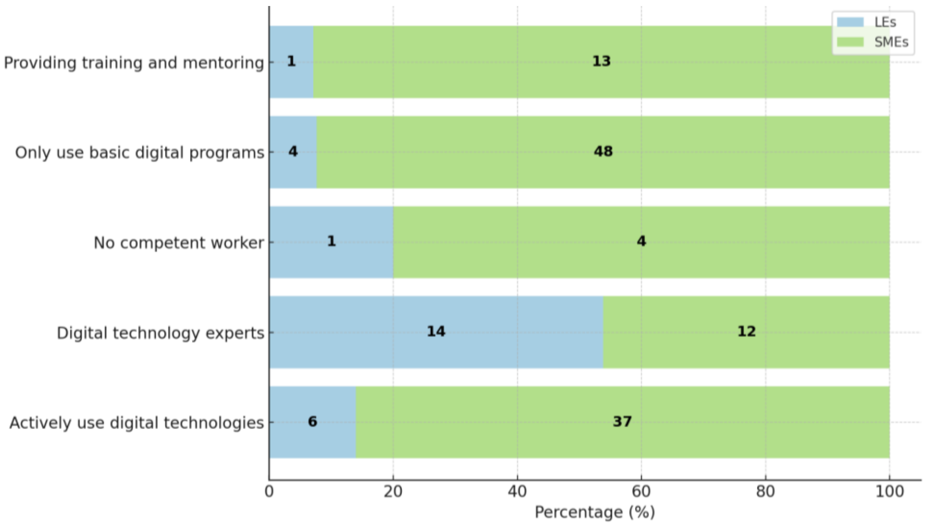

Figure 4-66: Digital competency level of employees (SMEs vs LEs)

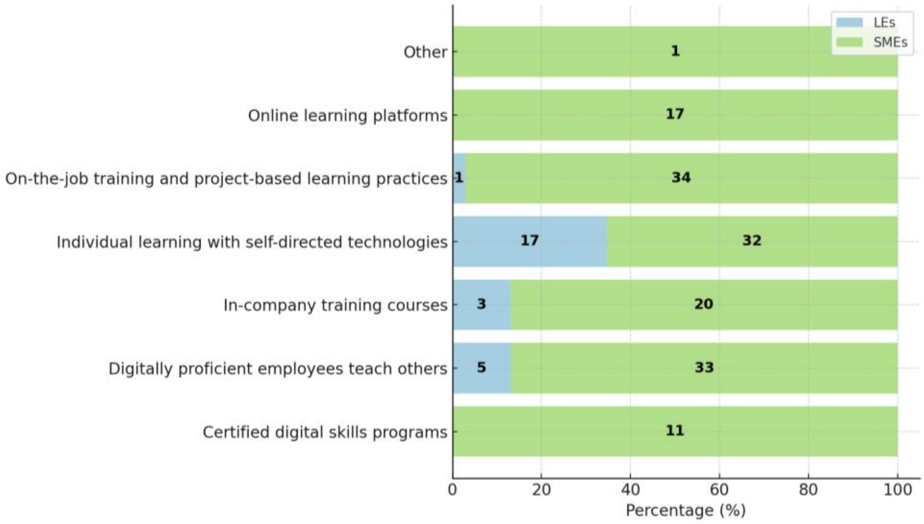

Figure 4-67: Methods to improve the digital skills of employees (SMEs vs LEs)

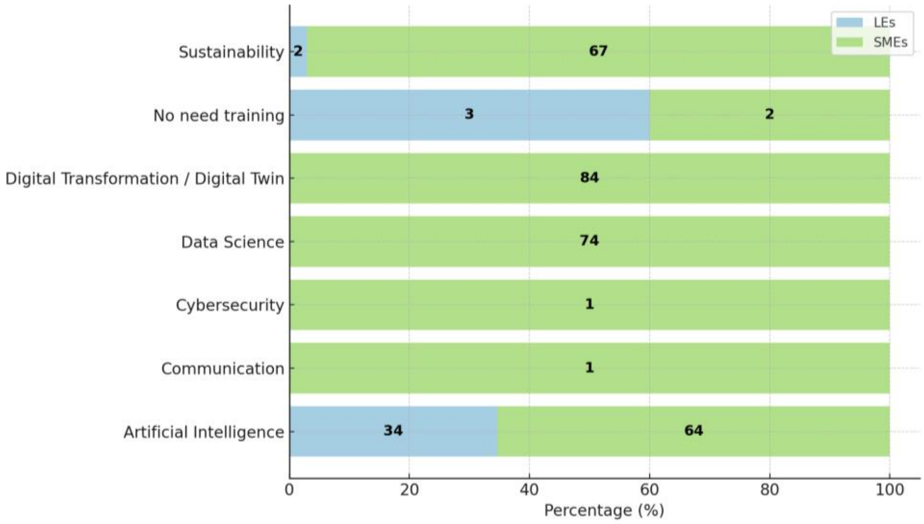

Figure 4-68: Demand for training topics (SMEs vs LEs)

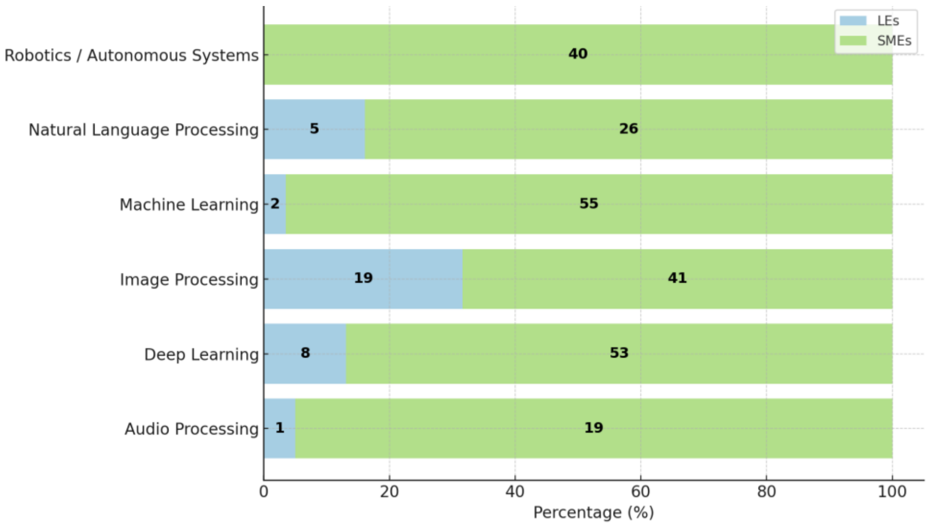

Figure 4-69: Demand for training topics – AI (SMEs vs LEs)

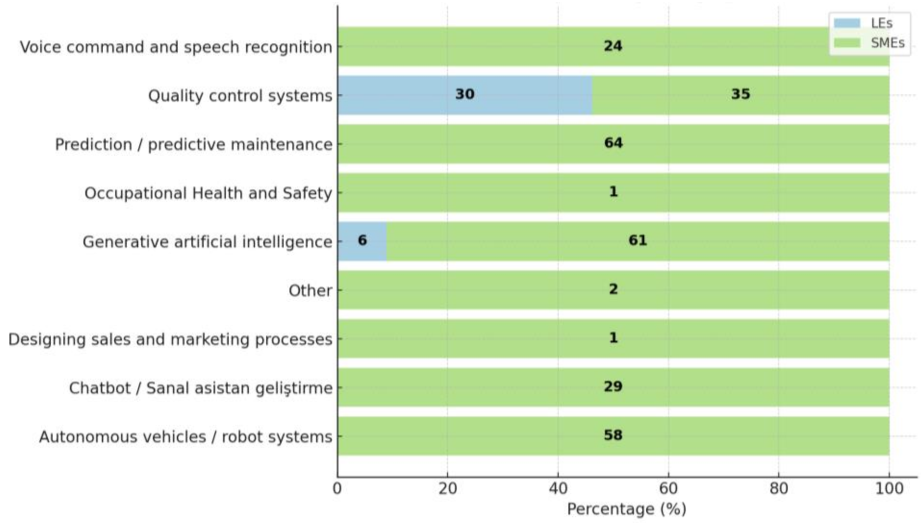

Figure 4-70: Demand for training sub-topics – AI (SMEs vs LEs)

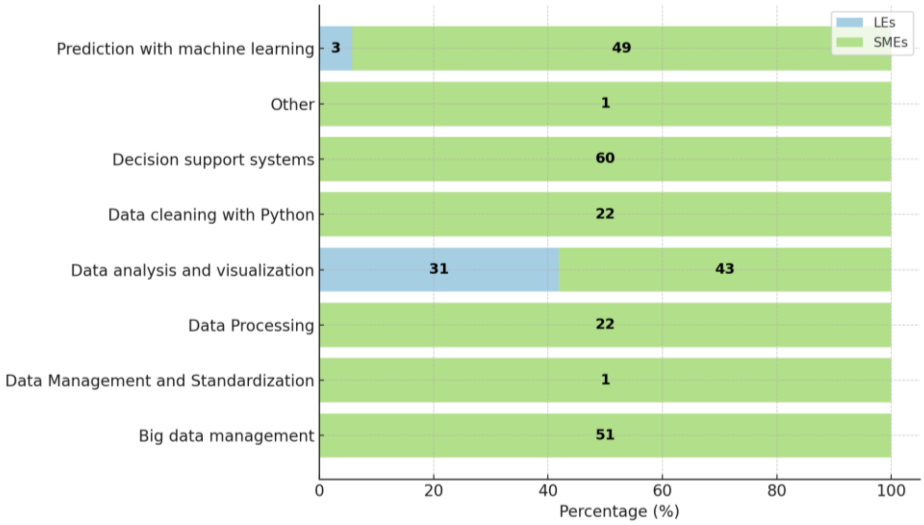

Figure 4-71: Demand for training topics – Data Science (SMEs vs LEs)

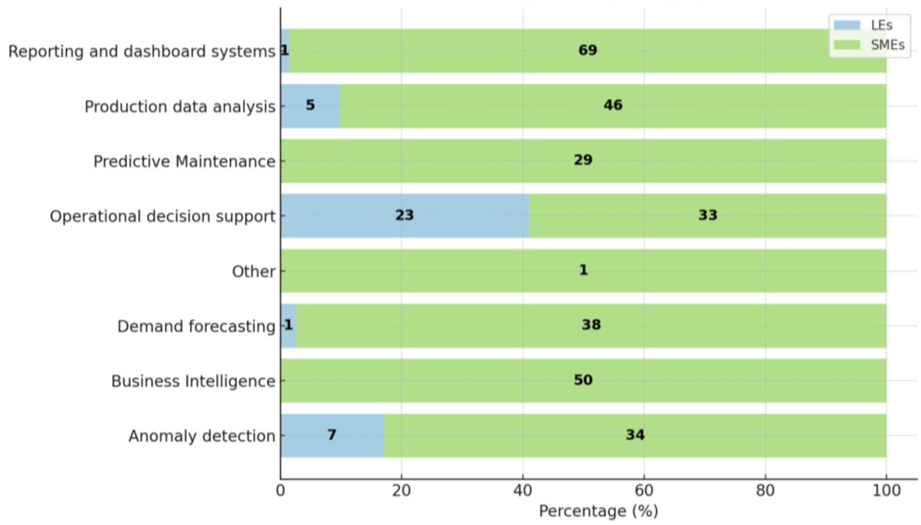

Figure 4-72: Demand for training sub-topics – Data Science (SMEs vs LEs)

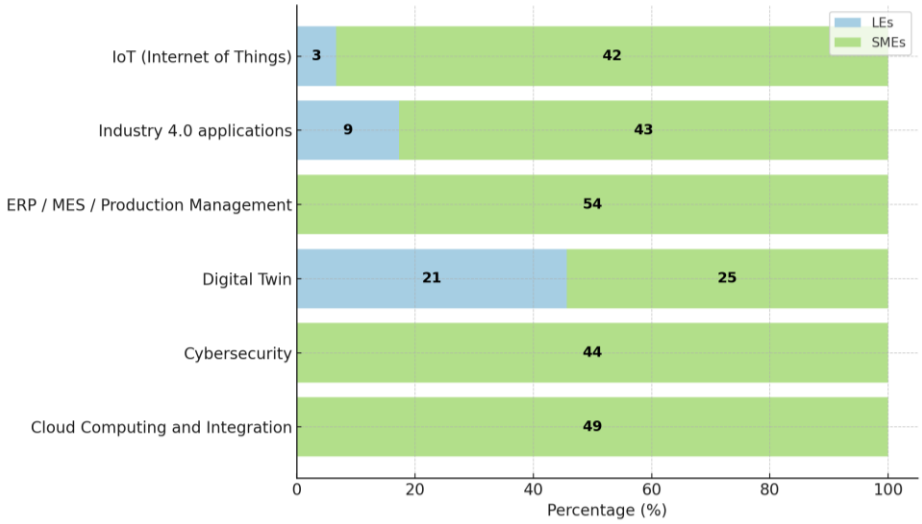

Figure 4-73: Demand for training topics (SMEs vs LEs)

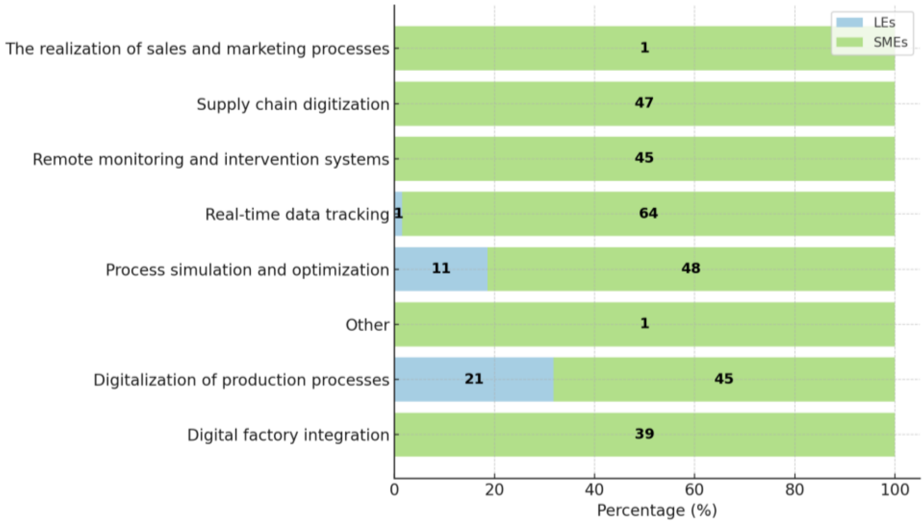

Figure 4-74: Demand for training topics – Digital transformation (SMEs vs LEs)

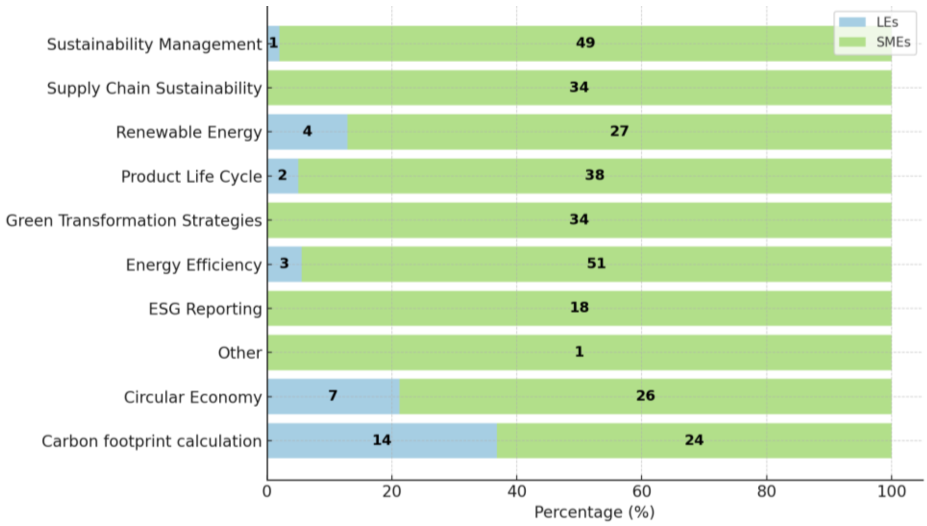

Figure 4-75: Demand for training topics – Sustainability (SMEs vs LEs)

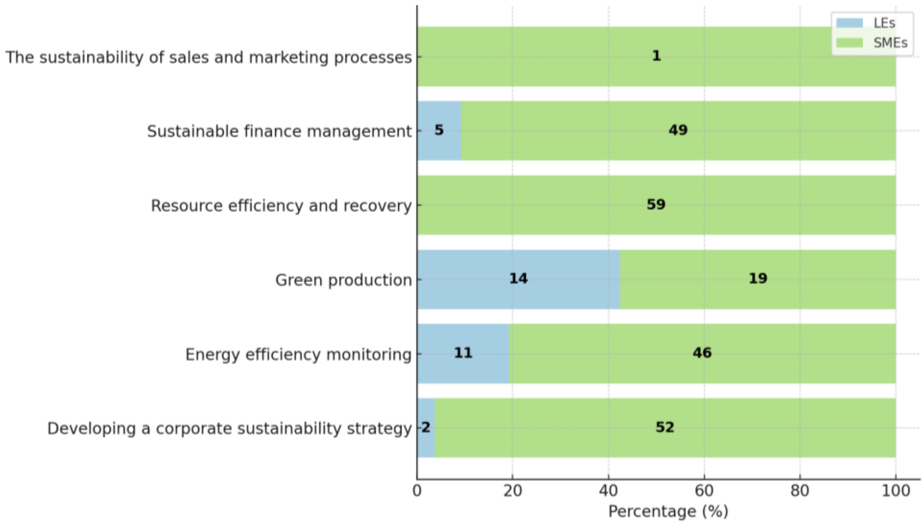

Figure 4-76: Demand for training sub-topics – Sustainability (SMEs vs LEs)

5. Analysis of Supply - Stakeholder Mapping for Upskilling

This chapter presents results on the internal capabilities of consortium stakeholders (training offers / courses by Project partners) to evaluate their readiness and capacity to deliver training aligned with identified needs. Table 5.1 shows that demand areas are covered by at least one existing training program. No demand areas remain completely uncovered, indicating strong baseline alignment.

While the existing training catalogue successfully addresses the breadth of identified demand areas, improvements can be introduced to enhance its depth and flexibility. Currently, each high-priority topic is covered by only one training offer, which limits learner choice, adaptability, and progression opportunities. To address this, the consortium can develop modular learning paths—offering beginner, intermediate, and advanced tiers—particularly for complex domains such as Artificial Intelligence, Predictive Analytics, and ESG reporting. Additionally, introducing parallel or alternative formats (e.g., webinars, self-paced modules, or sector-specific workshops) would better accommodate the diverse learning needs and time constraints of SMEs. Tailored content for key sectors would further increase relevance and uptake. These enhancements will not only deepen impact but also ensure continuity, scalability, and better alignment with the Digital Europe Programme's long-term objectives.

Table 5-1: Training offers from internal stakeholders

Course Title	Artificial Intelligence Awareness Training	AI and Machine Learning Training	AI Deep Dive Trainings	Data Science Training	Computer Vision and Deep Learning Training	Digital Transformation Trainings	Sustainability Trainings	Innovation Leadership Training
Offering Partner(s)	ITU, MESS/MEXT	Bilkent	ITU	ITU, MESS	Bilkent	MESS/MEXT Technology Center	MESS/MEXT Technology Center	ICI
Focus Area	Artificial Intelligence	Artificial Intelligence	Artificial Intelligence	Data Science	Artificial Intelligence	Digital Transformation	Sustainability	Digital Transformation

Sub-Thematic Tags	AI Fundamentals, AI Ethics, Trends & Use Cases	Machine Learning, Probabilistic Reasoning, Optimization	Smart Manufacturing, AI Automation, Predictive Maintenance	EDA, Predictive Modeling, Data-driven Decisions	Image Recognition, Deep Learning, Automation	Digital Leadership, IoT, Robotics, Smart Automation	Life Cycle Assessment, Circular Economy, Hydrogen	Leadership, Innovation KPIs, Strategy
Training Type	Lecture-based training (3 levels)	Lecture + Hands-on training	Lectures + Case Studies	Lectures + Real-world Cases	Blended Learning	Lecture & Factory Tour	Lectures + Industry Cases	Training
Delivery Mode	In-person / Online (flexible)	In-person	In-person	In-person	Hybrid	In-person	In-person	Online or In-class
Duration	Level I & III: 1 Day, 8 Hours; Level II: 3 Days, 24 Hours	12 Hours	9 Hours per module	12 Hours	12 Hours	2 Days per module	2 to 5 Days (depending on module)	2 hours (online) / 1 full day (in-class)
Delivery Frequency	Upon request (registration 1 month prior)	Not specified	6 times/year	3 times/year	Not specified	Flexible (1 month pre-registration)	Flexible	Not specified
Target Audience	SMEs, public orgs, NGOs; Level-based segmentation	SMEs, start-ups, spin-offs, scale-ups	SMEs, tech providers, universities	SMEs, scale-ups, universities	SMEs, start-ups	Employees of SMEs, public orgs, engineers, managers	Industry professionals	Employees and managers
Learning Outcomes	AI concepts, ethics, tools, strategic integration	Apply AI/ML in business processes	Practical applications in AI-driven manufacturing	Build and apply predictive models using data	Apply CV/DL to automate and optimize processes	Understand and lead digital transformation	Understand sustainability challenges and tools	Innovation-oriented leadership skills
Prerequisites /Level	Level I: General; Level II: Technical teams; Level III: Mid-level managers	Not specified	Industry practitioners, basic AI familiarity	Beginner to intermediate	Technical background preferred	Mixed: General to Engineering	General to Managerial	General
Fee Structure	110,000 TL + VAT (Level I & III); 330,000 TL + VAT (Level II); per group	80 EUR/hour + taxes + travel (1 expert)	1000 Euro + VAT per group (up to 20 people)	1800 Euro + VAT per group (20 people)	80 EUR/hour + taxes + travel (1 expert)	110,000–210,000 TL + VAT per group	210,000 TL + VAT (2-day); 4000 EUR/person (5-day)	Free (online); €100/person (in-class)
Maximum Participants	Not specified	Not specified	20	20	Not specified	Not specified	Not specified	30 (in-class), unlimited (online)
Certification	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified
Expected Impact	Upskilling for AI integration and leadership	Integration of AI tools into operations	Improved productivity and competitiveness	Data-driven innovation and efficiency	Operational efficiency via CV/DL	Upskilling, digital integration, productivity	Support green transition and ESG adoption	Sustained innovation capability
Customization Option	Yes	Not specified	Yes	Yes	Yes	Yes	Yes	Not specified
Application/Registration Process	Registration required 1 month before	Not specified	Not specified	Not specified	Not specified	1 month in advance	1 month prior	Not specified
Tools & Methods	Python, AI Navigator, Explainable AI, Agile	Data-driven AI, ML algorithms	Smart platforms, AI analytics	EDA, Machine Learning, Data Visualization	Python, Neural Networks, CV Toolkits	Digital Factory Simulation, RPA, SCADA, PLC	Sustainability KPIs, Energy Mgmt Tools	Innovation Typologies, KPI Management

Course Title	Design Thinking Workshop	Sustainability Mini MBA	Sustainable Finance Mini MBA	Circular Economy Mini MBA	R&D Management Mini MBA Program	Agile Project Management Training	Next Generation Technologies and Investment Mini MBA	Soft-Skills Trainings
Offering Partner(s)	MESS/MEXT Technology Center	ICI	ICI	ICI	ICI	ICI	ICI	ITU
Focus Area	Digital Transformation	Sustainability	Sustainability	Sustainability	Digital Transformation	Digital Transformation	Digital Transformation	Artificial Intelligence
Sub-Thematic Tags	Design Thinking, Innovation, Prototyping	Green Deal, Circular Economy, Innovation	Green Finance, ESG, Risk Management	Circular Business Models, Green Deal, Supply Chains	Technology Trends, R&D, Project & Finance Mgmt	Agile, Scrum, Product Development	Tech Trends, Venture Capital, Legal Structures	Self-awareness, Communication, Psychology of Success
Training Type	Workshop	Mini MBA	Mini MBA	Mini MBA	Mini MBA	Training (Lecture + Case)	Mini MBA	Lecture + Experiential Learning
Delivery Mode	Online / In-class	Hybrid (In-class / Online)	Hybrid (In-class / Online)	Hybrid (In-class / Online)	Online or In-class	Online or In-class	Online or In-class	In-person
Duration	2 Days	18 Hours (2 days/week)	24 Hours (2 days/week)	36 Hours (2 days/week)	3–4 weeks, 18–36 hours	3 hours (online) / 1 day (in-class)	3–4 weeks, 18–36 hours	9 Hours
Delivery Frequency	Flexible	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	6 times/year
Target Audience	Corporate teams, SMEs	General participants incl. SMEs	General participants incl. SMEs	Sustainability, Engineering, Marketing, etc.	SMEs, startups, students	Managers and employees at all levels	SMEs, investors, tech enthusiasts	SMEs, start-ups, universities
Learning Outcomes	Hands-on design thinking application	Understand sustainability frameworks and strategy	Financial strategies for sustainable development	Enable circular economy transition in companies	Systematic R&D and innovation leadership	Practical knowledge of Agile & Scrum	Knowledge on tech investments & startup ecosystem	Enhanced interpersonal and communication skills
Prerequisites /Level	General	General	General	General	General	General	General	General
Fee Structure	€6,000 (in-class); €5,500 (online) per 12–18 participants	Not specified	Not specified	Not specified	Free (online); €200/person (in-class)	Free (online); €100/person (in-class)	Free (online); €200/person (in-class)	1000 Euro + VAT per group (up to 20 people)
Maximum Participants	18	30 (in-class), unlimited (online)	30 (in-class), unlimited (online)	30 (in-class), unlimited (online)	30 (in-class), unlimited (online)	30 (in-class), unlimited (online)	30 (in-class), unlimited (online)	20
Certification	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified
Expected Impact	Innovative solution generation	Enhanced sustainability leadership in SMEs	Better financial resilience through sustainability	Business innovation and sustainability compliance	Empowered R&D capacity in industry	Agile practices adoption and project efficiency	Participation in tech investment landscape	Improved team dynamics and motivation
Customization Option	Yes	Not specified	Not specified	Not specified	Yes	Not specified	Not specified	Yes

Application/Registration Process	1 month prior	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified	Not specified
Tools & Methods	HPI Design Thinking Model	System Thinking, Strategy Design	Sustainable Reporting, Climate Finance	Green Procurement, EU Regulation Alignment	Feasibility, DuPont, IP Strategy	Scrum, Agile Planning	Investment Models, Legal Frameworks	Who-is-Who, Experiential Design, Neurological Styles

6. Main Principles for the Design of the Training Program

The design of the training program is guided by evidence from both demand-side (survey analysis of SMEs – see Section 4) and supply-side (mapping of partner training proposals – see Section 5). The following principles have been identified to ensure the training services are relevant, accessible, and impactful:

- *Segmented Learning Pathways According to Digital Maturity* - Training content must be tailored to enterprises' digital maturity levels to ensure effective learning:

  Beginner: Basic digital literacy and foundational concepts (e.g., AI awareness).

  Intermediate: Applied tools and technologies in current workflows (e.g., ERP, IoT).

  Advanced: Integration of AI, data analytics, and digital twins in strategic processes.

This segmentation allows participants to advance progressively and prevents knowledge overload for less digitally mature firms.

- Firm *Size Sensitivity in Design* - In addition to digital maturity, findings show that SMEs and LEs show distinct patterns in their training formats, internal capacity, and technological adoption. SMEs benefit more from operationally focused, modular formats, while LEs may require more strategic, cross-departmental programs leveraging their broader internal capabilities.

- *Differentiated Content for Distinct Roles: Managers vs Technical Staff* - There is a clear distinction in learning needs between decision-makers and implementers. Training modules should reflect this differentiation (see Table 6.1)

Table 6-1: Differentiation of training according to targeted groups

Dimension	Training for Managers	Training for Technical Staff
Goal	Strategic awareness, enhancement of decision support capacity, transformation leadership	Development of practical skills, competence in system setup and operation
Content Level	Conceptual, high-level summaries (e.g., What does AI provide, when should one invest?)	In-depth technical knowledge (e.g., algorithm selection, Python programming)

Focus	Business model transformation, data-driven decision-making, competitive advantage	System setup, integration, analysis, optimization
Delivery Methods	Case studies, scenario discussions, interactive debates	Coding, simulations, hands-on lab work
Presentation Style	Strategic seminars, leadership workshops, panel sessions	Technical workshops, live software implementation, e-learning modules
Expected Outcomes	Ability to guide investment decisions, set strategic priorities	Ability to implement, optimize, and debug systems
Preferred Duration	Short and concise seminars (half-day)	Medium to long (1–3 day) intensive hands-on modules
Assessment Methods	Strategic decision simulations, group discussions	Technical exam, project presentations, hands-on mini tests

- *Companies prefer intensive, short-term, sector-focused, and hands-on training over long-term programs*.
- *Flexible and Modular Delivery Formats* - Survey responses emphasize a preference for **short, intensive, sector-specific, and applied formats** over long-term academic-style courses. Training offerings should include:
  - Awareness Level: 1–2-hour webinars, short online self-paced modules.
  - Applied Skills: Half-day to full-day hands-on workshops.
  - Intensive Programs: 2–3-day deep dive modules (e.g., over weekends).

Hybrid formats (online + in-person), workplace-integrated learning, and micro-credentials are encouraged to enhance accessibility and impact

- *Prioritized Thematic Areas* - Training programs should address the most demanded areas identified in the survey, including:
  - Artificial Intelligence: Machine Learning, Deep Learning, Computer Vision, Predictive Maintenance.
  - Data Science: Data visualization, predictive analytics, operational dashboards.
  - Digital Transformation: ERP integration, IoT, cybersecurity, process automation.
  - Sustainability: ESG reporting, green manufacturing, sustainable finance, circular economy.

Each theme should be linked to concrete industrial use cases to demonstrate relevance and application potential.

- *Customizable and Scalable Training Offers* – To maximize value for companies, training modules should allow for customization based on:
  - Sector-specific needs (e.g., manufacturing, energy, construction).

- Company size (micro, small, medium).
- In-house capability levels.

Manufacturing SMEs, across micro, small, and medium sizes, exhibit a clear preference for flexible and impactful training. While shorter, easily digestible formats like short web seminars are highly valued for their convenience, there's also a significant demand for more comprehensive multi-day programs, especially within the manufacturing sector itself. This suggests a need for both targeted, quick learning and more in-depth, skill-building opportunities. Training that occurs "after work" is consistently unpopular, highlighting the importance of considering employees' time and work-life balance when designing training initiatives.

Blended learning and company-specific tracks (e.g., factory visits, use-case mentoring) will support deeper adoption.

- *Inclusive Learning Across Departments* - Training should not be limited to technical departments. Respondents identified multiple units that would benefit from capacity building:
  - C-level executives
  - Mid-level management
  - Engineers and IT personnel
  - Production staff
  - Office administration

Training should offer entry points for diverse professional roles and promote organization-wide digital literacy.

- *Alignment with Internal and External Training Supply* - Existing training proposals from consortium partners provide a strong foundation. However, gaps—particularly in flexible delivery, microlearning, sector-specific AI applications, and interdisciplinary sustainability skills—should be filled through external partnerships (e.g., expert consultants, online platforms)
- *Performance-Oriented and Measurable Outcomes* - Programs should define clear learning outcomes, assessment methods, and measurable KPIs (e.g., skill adoption, pilot implementation, upskilled staff ratio). Certification options and digital badges may help increase learner motivation and track progress.

To ensure the effectiveness and continuous improvement of the training programs, a robust monitoring and evaluation framework will be implemented. Key performance indicators (KPIs) will track metrics such as participant uptake rates, completion rates, post-training satisfaction, and self-reported skill improvements. For pilot sessions, structured feedback forms and follow-up interviews will be conducted with selected participants to assess the relevance, quality, and applicability of the training content. In addition, pre- and post-training assessments may be utilized to measure knowledge gains in targeted modules. These insights will be used to refine training content, delivery methods, and customization strategies in subsequent iterations, ensuring the programs remain demand-driven, impactful, and aligned with SME needs. Based on evidence from the previous sections, Table 6.2 below summarizes the overall process.

Table 6-2: Roadmap for the trainings

Action	Description	Output
Curriculum modules	Tiered training modules (beginner–intermediate–advanced) for high-demand areas	Course templates
Pilot Program Implementation	Launch pilot trainings with SMEs, incorporating diverse formats (online, hybrid, hands-on).	Pilot participant feedback reports
Feedback & Evaluation Loop	Use pre/post assessments, pilot feedback, and learning analytics to evaluate effectiveness	Evaluation report and revision plan
Stakeholder Engagement Workshops	Conduct workshops to update needs analysis and collect feedback on content relevance.	Workshop summaries and updates to training catalogue
Expansion of Training Catalogue	Address uncovered or underrepresented sub-topics	Updated and extended catalogue
Certification	Define assessment criteria and design certification mechanisms for each module	Certification protocols
KPI Tracking	Monitor participation, completion rates, and upskilling metrics	Monitoring dashboard

7. Conclusion

This report provides an integrated and evidence-based foundation for the design of targeted training programs that support the digital and green transformation of the SMEs. Grounded in both a detailed demand analysis through a survey and a comprehensive mapping of existing training offers, the findings illuminate the critical gaps in digital capabilities in Artificial Intelligence, Data Science, Digital Transformation, and Sustainability.

The analysis reveals that SMEs exhibit varied levels of digital maturity and that their training needs differ by size, sector, and employee profile. There is a pronounced preference for flexible, modular, and hands-on training programs—delivered in short, intensive formats tailored to the operational realities of SMEs. Equally important is the need to differentiate content for technical staff and managerial roles, while ensuring inclusivity across departments such as engineering, operations, HR, and executive leadership.

Across all focus areas, manufacturing SMEs demonstrated the highest demand for training in ERP/MES integration, cybersecurity, and predictive maintenance—highlighting a clear priority to optimize production efficiency and ensure operational resilience. These firms also strongly favored practical, hands-on formats that align with the realities of industrial shop floors and shift-based workflows. The training priorities of manufacturing SMEs clearly align with strategic imperatives for industrial modernization. Their preferences underscore a growing recognition that digital and AI capabilities are not optional add-ons, but critical assets for long-term value creation in the manufacturing sector.

The stakeholder mapping exercise shows that AI EDIH Türkiye partners offer a strong foundation of upskilling services, though gaps remain in sector-specific applications, microlearning options, and interdisciplinary modules. To address these challenges, future training programs must adopt a performance-oriented, customizable, and scalable structure, while also leveraging partnerships with external experts and platforms.

Looking ahead, the findings of D4.1 will directly inform the design and delivery of WP4 training modules (D4.2 and D4.3), helping to ensure that capacity-building efforts are responsive, aligned with industry needs, and supportive of Türkiye's strategic priorities under the Digital Europe Programme and the twin transition agenda. As the project advances, continuous monitoring, stakeholder feedback, and agile iteration will be essential to ensure the training ecosystem evolves in step with the technological and policy landscape.

Moreover, the analysis underscores the need for differentiated training strategies for SMEs. While both SMEs and LEs share an interest in applied, hands-on content, their digital capacities, internal resources, and preferred formats vary significantly. To ensure effectiveness and uptake, training design must integrate these differences into both content and delivery modes.

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Annex

AI EDIH TURKEY – Digital Transformation and AI Training Needs Survey (EN)

This form has been prepared as part of the AI EDIH Turkey Project, supported under the European Commission's Digital Europe program, to identify training needs for free Artificial Intelligence and Digital Transformation courses aimed at supporting SMEs in their digital and green transformation processes.
Target Audience: Small and medium-sized enterprises (SMEs) and individual employees working in those companies.
Purpose: The objective is to identify institutional or individual training needs in relevant areas to shape the free training programs offered under the EU-funded AI EDIH Turkey (AI-Enabled Manufacturing for Twin Transition) project.
Who should fill out this survey: Company representatives (managers, HR officers, training and development coordinators, etc.) and/or individual employees.
Privacy and Data Security: The data collected in this survey will be used solely for statistical analysis purposes and no personal information will be shared with third parties. Participant confidentiality is protected under the Turkish Personal Data Protection Law (KVKK).
Consent Statement: I hereby accept, declare, and undertake that the information I provide in the form below may be processed, stored, used, and shared with relevant parties and institutions when necessary by the project coordinator MESS and the relevant work package leader ITU, in accordance with Law No. 6698 on the Protection of Personal Data and the above-mentioned explanations and purposes.
Duration: Completing this survey will take approximately 4–5 minutes. Please complete it by June 16, 2025.
(*) Indicates a mandatory question

PERSONAL INFORMATION

1. Name
2. Email *
3. Phone number
4. Company Name *
5. Company Sector *
6. What is the size of your company based on the number of insured employees? *

   - Micro enterprise (<10 people)
   - Small enterprise (10–49 people)
   - Medium enterprise (50–249 people)
   - Large enterprise (>250 people)

7. Which of the following best describes your current job position? *

   - Senior Management
   - Director
   - Manager
   - Technical Expert / Engineer
   - IT (Information Technology) Staff
   - Field Worker / Production Staff
   - Office Staff
   - Other

8. What is your role within the company? *

   - Company Representative (e.g., Manager, HR officer, Training Coordinator)

- Individual Employee

DIGITAL MATURITY

9. How would you evaluate your company's current level of digital maturity?

- Initial – Only basic Information Technology (IT) tools are being used.
- Developing – Some digital tools have started to be actively used.
- Advanced – Digital systems have been integrated and embedded in business processes.
- Leading – AI and advanced analytics are used in strategic decision-support systems.

10. For which purposes does your company use digital technologies?

- Customer communication (CRM, website, social media)
- Accounting processes like invoicing and inventory
- Collaboration processes with other companies (via websites)
- Automating repetitive and high-risk tasks
- Designing new products and services
- Forecasting future decisions and actions
- Human resources (digital payroll, leave tracking, meeting room booking, etc.)
- Other

DIGITAL COMPETENCIES & TRAINING METHODS

11. What types of digital competencies do your employees possess?

- We have advanced digital technology specialists who analyze, improve, and develop systems.
- We have professional staff actively using digital technologies.
- We have employees who provide training and mentoring on technology-related topics.
- We have staff who only use basic digital tools.
- We do not have employees with these competencies.

12. Which methods do you use to improve your employees' digital competencies?

- Employees use self-learning technologies to manage their own learning.
- Experienced staff teach others in digital technologies.
- We organize in-house training programs on digitalization.
- We support training via platforms like Udemy or Coursera.
- We encourage participation in certified digital skill programs.
- We implement on-the-job and project-based learning practices.
- Other

TRAINING & PRIORITY DEPARTMENTS

13. Which of the following departments in your organization could benefit from training in Artificial Intelligence, Digital Transformation, or Sustainability?

- Senior Management
- Directors
- Managers
- Technical Experts / Engineers

- IT (Information Technology) Staff
- Field Workers / Production Staff
- Office Workers

14. Please indicate in which of the following areas you or your organization need training:

- Artificial Intelligence
- Digital Transformation / Digital Twin
- Sustainability
- Data Science
- We currently do not have a need for training in these areas
- Other

ARTIFICIAL INTELLIGENCE

15. Which subfields of artificial intelligence do you or your organization need training in? (Select up to 3)

- Computer Vision
- Speech Processing
- Natural Language Processing
- Deep Learning
- Machine Learning
- Robotics / Autonomous Systems
- Other

16. Which application areas should AI training also cover? (Select up to 3)

- Quality control systems
- Generative AI (chatbots, content creation, etc.)
- Voice command and speech recognition
- Chatbot / Virtual assistant development
- Forecasting / Predictive maintenance
- Autonomous vehicles / robotic systems
- Other

DATA SCIENCE

17. Which subfields of data science do you or your organization need training in? (Select up to 3)

- Data analysis and visualization
- Data cleaning and processing with Python
- Predictive modeling with machine learning
- Big data management
- Decision support systems
- Other

18. Which application areas should data science training also cover? (Select up to 3)

- Operational decision support
- Anomaly detection
- Demand forecasting

- Production data analysis
- Reporting and dashboard systems
- Business Intelligence
- Predictive Maintenance
- Other

DIGITAL TRANSFORMATION

19. Which subfields of digital transformation do you or your organization need training in? (Select up to 3)

- Digital Twin
- Industry 4.0 applications
- IoT (Internet of Things)
- Cloud Computing and Integration
- ERP / MES / Production Management
- Cybersecurity
- Other

20. Which application areas should digital transformation training also cover? (Select up to 3)

- Digitization of production processes
- Process simulation and optimization
- Real-time data monitoring
- Supply chain digitization
- Digital factory integration
- Remote monitoring and intervention systems
- Other

SUSTAINABILITY

21. Which subfields of sustainability do you or your organization need training in? (Select up to 3)

- Carbon footprint calculation
- Renewable energy
- Circular economy
- Energy efficiency
- Green transition strategies
- Product life cycle
- Sustainability management
- Sustainable supply chain
- ESG (Environmental, Social, Governance) reporting
- Other

22. Which application areas should sustainability training also cover? (Select up to 3)

- Green production
- Energy efficiency monitoring
- Sustainable financial management
- Resource efficiency and recovery
- Development of corporate sustainability strategies
- Other

TRAINING FORMAT & DURATION

23. What is your preferred training format? (Multiple selections allowed)

- In-person training
- On-site workshops
- Online live sessions
- Self-paced e-learning
- Blended learning (online + in-person)
- Hands-on training
- Other

24. What is your preferred training duration? (Multiple selections allowed)

- 1–2-hour short webinar
- Half-day
- Full-day
- Multi-day program
- After work hours
- Full-day on weekends
- Other

ADDITIONAL COMMENTS

25. You may share any additional comments or notes here.