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INDICE

6. DIGITAL TRANSFORMATION: PROCESSES, ORGANISATIONAL MODELS AND OSH TRAINING

by Sara Stabile, Rosina Bentivenga, Emma Pietrafesa, Edvige Sorrentino, Margherita Bernabei, Silvia Colabianchi, Francesco Costantino*

Abstract: Questo articolo analizza l'impatto della trasformazione digitale sulla gestione della salute e sicurezza sul lavoro (SSL) all'interno delle aziende manifatturiere italiane. Lo studio condotto nell'ambito del progetto FEREO, indaga come le organizzazioni stiano adattando i propri modelli organizzativi e le strategie formative in ambito SSL in risposta all'innovazione tecnologica. Viene posta particolare attenzione all'innovazione dei processi formativi e ai relativi obiettivi, contenuti, metodologie e modalità di erogazione e valutazione, al fine di garantire un efficace e continuo aggiornamento e una riqualificazione delle competenze della forza lavoro. Il lavoro sottolinea l'importanza di allineare la formazione alla SSL sia ai progressi tecnologici sia agli aggiornamenti normativi introdotti dal nuovo Accordo Stato-Regioni 2025. Lo studio contribuisce alla comprensione di

* Sara Stabile, Senior Researcher, Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, sa.stabile@inail.it; Rosina Bentivenga, Researcher, Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, r.bentivenga@inail.it; Emma Pietrafesa, Senior Researcher, Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, e.pietrafesa@inail.it; Edvige Sorrentino, Researcher, Department of Occupational and Environmental Medicine, Epidemiology and Hygiene, INAIL, e.sorrentino@inail.it; Margherita Bernabei, Post-doctoral researcher, Department Mechanical and Aerospace Engineering Sapienza University of Rome, margherita.bernabei@uniroma1.it; Silvia Colabianchi, Associate Professor, Department of Engineering and Science Universitas Mercatorum, silvia.colabianchi@unimercatorum.it; Francesco Costantino, Full Professor, Department of Computer, Control, and Management Engineering "Antonio Ruberti" Sapienza University of Rome, francesco.costantino@uniroma1.it.

come la digitalizzazione ridefinisca la governance della SSL e favorisca lo sviluppo di sistemi formativi di qualità, resilienti e orientati al futuro.

Parole chiave: Salute e sicurezza sul lavoro, Digitalizzazione, Formazione, Settore Manifatturiero.

Abstract: This article examines the implications of digital transformation for the management of occupational safety and health (OSH) in Italian manufacturing companies. Developed within the framework of the FEREO project, the study investigates how organisations are adapting their organisational structures and OSH training strategies in response to technological innovation. Particular emphasis is placed on the evolution of training processes, including objectives, content, pedagogical methodologies, delivery modalities, and evaluation mechanisms, with the overarching goal of ensuring effective and continuous upskilling and reskilling of the workforce. The paper underscores the importance of aligning OSH training frameworks with both ongoing technological advancements and the regulatory developments introduced by the 2025 State–Regions Agreement. By doing so, the study contributes to a more comprehensive understanding of the ways in which digitalisation is reshaping OSH governance and fostering the development of high-quality, resilient, and future-oriented training systems.

Keywords: Occupational Safety and Health (OSH), Digitalisation, Training, Manufacturing Sector.

Introduction

The United Nations Agenda for Sustainable Development, adopted on 25 September 2015 and comprising 17 goals to be achieved by 2030, emphasises the need for a sustainable pathway to global development that fully integrates environmental, economic, and social dimensions (United Nations General Assembly, 2015). In

particular, Goal 4 seeks to ensure inclusive, equitable, and high-quality education and to promote lifelong learning opportunities for all, underlining the pivotal role of education and training in improving the living conditions of individuals, communities, and societies. Within this international framework, transformations in the world of work driven by sociodemographic changes, market globalisation, technological innovation, and digitalisation present significant opportunities for development and enhanced business competitiveness. At the same time, these processes entail a profound reconfiguration of work and production systems, including the emergence of new business models and occupational hierarchies. Such developments generate new paradigms for workers in terms of tasks, roles, and skill requirements, with important implications for Occupational Safety and Health (OSH) (Stabile *et al.*, 2017; EU-OSHA, 2018). Concurrently, the European Union's strategy for the period 2021–2027 (European Union, 2021) highlights the importance of anticipating and managing changes in the world of work arising from the green, digital, and demographic transitions. In alignment with this perspective, the 2030 Agenda for Sustainable Development underscores the necessity of a global development model grounded in the integration of environmental, economic, and social dimensions. Within this context, Goal 4 reinforces the centrality of inclusive, equitable, and high-quality education, together with lifelong learning, as key drivers of individual and societal well-being.

The world of work is undergoing profound transformations driven by sociodemographic shifts, market globalisation, and rapid technological and digital innovation. These dynamics, while enhancing opportunities for development and organisational competitiveness, are reshaping work structures, production processes, and organisational models. As a result, new occupational roles, task configurations, and skill requirements are emerging, with

significant implications for OSH (Stabile *et al.*, 2017; EU-OSHA, 2018). Similarly, the European Strategy for 2021–2027 (European Union, 2021) underscores the need to anticipate and manage the effects of the green, digital, and demographic transitions on work and employment. The centrality of lifelong learning is further reaffirmed in the European Digital Agenda 2030 (European Commission, 2025) and the European Pillar of Social Rights (European Commission, 2017), which recognise the right to education and training as essential for acquiring and maintaining the skills required for active participation in society and for navigating labour market transitions.

From this perspective, OSH training represents a strategic lever for ensuring that digital and green transitions remain socially just, enabling productivity gains to be aligned with the protection of workers' rights, employability, and overall well-being.

Recent European foresight studies on digitalisation emphasise that innovative technologies entail both opportunities and vulnerabilities, thereby requiring anticipatory, systematically designed, and worker-centred training strategies (EU-OSHA, 2024; International Labour Organization, 2025). Such strategies should integrate technical, organisational, and psychosocial dimensions of work and be continuously updated on the basis of monitoring and evaluation outcomes.

Within this framework, the present study, conducted as part of the FEREO project (FEREO, 2022) and funded by INAIL, examines how Italian manufacturing companies are implementing and perceiving organisational changes associated with the introduction of new digital technologies. The analysis focuses on the evolution of organisational models, companies' experiences of these transformations, and the ways in which OSH training has been reshaped in terms of objectives, content, methodologies, and delivery modes. Specifically, the study investigates:

- actions undertaken by companies about data management and security, privacy protection, digital ethics, sustainability, inclusion, participation, and skills development;
- changes in roles and responsibilities, work environments, workloads, communication flows, emergency management, incident analysis, risk assessment, and monitoring processes related to environmental conditions, equipment and machinery, and production and administrative activities;
- modifications to OSH training objectives, content, methods, and methodologies following technological innovation.

1. Requirements for Occupational Safety and Health Training

Legislative Decree 81/2008 and its subsequent amendments (Decreto Legislativo n. 81, 2008), which constitute the current regulatory framework for occupational safety and health, assign a central role to information, education, and training. By promoting the active participation of all individuals involved in a company's prevention system, these processes represent one of the most effective means of preventing occupational diseases and workplace accidents. The decree not only provides formal definitions for information, education, and training, but also extends the obligation to provide both initial and refresher training to all personnel engaged in health and safety management, thereby fostering a continuous learning process. This underscores the importance of training within an increasingly integrated and comprehensive corporate prevention system. According to Article 30 of Legislative Decree 81/2008 and its subsequent amendments (Decreto Legislativo n. 81, 2008), well-implemented information and training programmes are essential for establishing an effective health and safety management system. Such a system forms the

foundation of the organisational and managerial model set out in Legislative Decree 231/2001 (Decreto Legislativo n. 231, 2001) and relies on the dissemination of information, the promotion of knowledge and risk awareness, open dialogue among stakeholders, and ongoing monitoring and evaluation of workplace outcomes (Dentici *et al.*, 2014).

The OSH training courses provided for under the Italian State-Regions Agreement (Conferenza Stato-Regioni, 2025) are designed and structured, regarding content, methodology, organisation, and procedures, in accordance with quality criteria of adequacy, specificity, and comprehensibility. They are strictly functional and tailored to the specific characteristics of the company roles they target, the tasks assigned to those roles, the risks to which employees are exposed, and the risk class associated with the company's economic activity. The quality and effectiveness of OSH training are closely linked to the adoption of models, tools, and criteria that enable the monitoring and assurance of all phases of the training process. A training provider authorised to deliver OSH training must implement internal organisational models that ensure the quality of training across all its aspects. Key references on the quality of non-formal vocational training (ISO, 2017; ISO, 2021; European Parliament and Council, 2009) emphasise the central importance of structuring training organisations through a process-based approach. This approach allows the provider to manage and control its processes and their interactions, thereby optimising activities and achieving adequate levels of performance and quality. Typically, a process-based approach relies on Deming's PDCA cycle (Isniah *et al.*, 2020) and ensures that processes are adequately resourced and managed, with a view to continuous improvement. Within the context of standard training production workflows, the process can be articulated into four distinct phases (Table 1):

Table 1: PDCA cycle and training process

PDCA cycle	*Training processes*	*Stages of the Training Process*
PLAN	PLANNING	Analysis of training needs - Planning
DO	IMPLEMENTATION	Provision
CHECK	MONITORING AND EVALUATION	Monitoring and evaluation of organisational and teaching quality
ACT	REVIEW AND ADOPTION OF IMPROVEMENT MEASURES	Review and adoption of corrective measures and interventions for improvement purposes

Source: Italian State-Regions Agreement 2025

Framing OSH training within a PDCA logic is consistent with the evolution of safety management systems towards learning-oriented and resilience-based models, in which organisations must both comply with regulations and observe how work is actually performed under variable conditions (Stabile *et al.*, 2025). Training thus becomes a core process that feeds back field experience, near misses, and good practices into the design and revision of preventive measures. Indeed, the analysis of OSH training needs takes the form of an assessment of "professional needs", aimed at identifying the specific competencies required by individuals involved in organising, managing, and improving corporate safety. The data and information derived from this needs analysis, as well as from the broader organisational context, serve as the input for the subsequent design of the training programme, translating identified needs into a coherent and relevant training response. During the design phase, the objectives, expected outcomes, training strategy,

and all elements necessary to define the detailed structure of the programme are established, including content, instructional methods, teaching materials, support tools, and assessment methods. Defining the training strategy involves selecting the most appropriate methodologies and tools in relation to the specific nature of the programme and its intended audience, considering that the training targets adults within a lifelong learning context.

An andragogical approach (Knowles, 1970) is essential to account for the specific characteristics of adult learning and engagement. Accordingly, active and interactive teaching methods should be employed to place learners at the centre of the learning process. The training programme must specify which active methods will be used throughout the course and within each teaching unit. Such methods, grounded in experiential and relational learning, are particularly effective for developing attitudes, analytical and problem-solving skills, and specific competencies. Content delivery should address real professional contexts rather than merely theoretical knowledge, and trainers should build on learners' prior experiences to enhance skill acquisition. Training implementation, the phase during which learning occurs, can be delivered through various modalities, including face-to-face instruction, e-learning, synchronous video conferencing (SVC), and blended learning. Face-to-face OSH training can take place in the classroom or directly in the workplace and is applicable to both initial and refresher courses. E-learning and SVC, however, are subject to specific technical and organisational requirements. While e-learning has been used in OSH training since 2011, SVC became widely adopted only during the COVID-19 pandemic, providing a delivery mode equivalent to face-to-face training. E-learning typically involves asynchronous remote learning with interactive elements among learners, instructors, and tutors via an IT platform with attendance tracking. Synchronous videoconferencing involves real-time interaction

between learners and instructors at multiple remote locations through a multimedia communication platform.

Promoting diverse approaches and learning contexts, including through digital technologies, supports the development of key competences, as emphasised in the European Council Recommendation on key competences for lifelong learning (Council of the European Union, 2018) and the European Digital Education Action Plan 2024–2027, Rethinking Education in the Digital Age (European Commission, 2018). Information and Communication Technologies (ICT) facilitate the creation of innovative learning spaces and methods, offering significant potential for enhancing OSH training (Handayani, 2025). Examples include augmented and virtual reality, immersive technologies that use mobile devices for viewing, listening, or manipulation to add multimedia information to the reality perceived naturally by the user (Bentivenga *et al.*, 2024a). Augmented reality (AR) enables learners to view digital elements superimposed on physical objects, whereas virtual reality (VR) immerses learners in a fully digital environment, isolating them from the external world. AR allows technical instructions to be provided remotely in real time and enables the testing of new, including complex, procedures. VR facilitates training sessions without the need for physical presence in a specific workplace and allows different scenarios to be simulated for educational purposes. These technologies simplify training activities by enabling real-time visualisation of information, repeated practice across multiple sessions, and reduced consequences of errors (Bentivenga *et al.*, 2024b). Virtual and physical simulators, including on-board machinery, are highly effective for developing manual and practical skills and can be integrated with innovative systems combining VR and AR software (Conferenza Stato-Regioni, 2025).

Gamification (Pietrafesa *et al.*, 2021) employs typical game mechanisms, particularly those derived from video games, to

enhance learner engagement, motivation, and attention. Serious games are designed with an explicit educational purpose rather than primarily for entertainment, although elements of enjoyment may be included (Abt, 1987). These games integrate declarative and procedural knowledge, balancing simulation, play, and training to enhance learning and engagement (Anolli e Confalonieri, 2011). Business games simulate a business environment and aim to develop decision-making skills, including the timeliness and effectiveness of choices, confidence in risky or uncertain situations, and the integration of different business functions (Jin *et al.*, 2020; Höhl, 2019). Virtual environments can also comprise three-dimensional spaces in which users navigate freely using avatars (the metaverse).

In OSH training, however, virtual or augmented reality does not replace the practical components of courses involving work equipment or confined/potentially hazardous environments (Conferenza Stato-Regioni, 2025). Finally, monitoring and evaluation are essential for observing, measuring, analysing, and interpreting key elements of training processes. This allows trainers to identify areas for improvement and implement corrective actions, supporting continuous improvement from both organisational and educational perspectives.

2. Materials and Methods

Literature analysis

A search and analysis were conducted for scientific articles addressing processes and organisational models affected by digital transformation, as well as innovative tools for OSH information and training, by consulting the online databases PubMed, Web of

Science, and Scopus. The following MeSH terms were used: “processes and organisational models”, “innovative tools”, and “OSH information and training”. The literature review highlighted several priority areas of interest, particularly concerning the types of technologies introduced, the nature of innovations implemented, and the various actions undertaken within organisational processes and OSH training.

Focus group for questionnaire development

The first step in developing the questionnaire involved forming a multidisciplinary focus group, carefully selected to ensure a broad range of expertise and perspectives relevant to the research topic. This foundational stage is critical for establishing the direction and approach of the inquiry (Asbury, 1995). A diverse mix of participants is a well-established prerequisite for an effective focus group. The group consisted of seven participants with varied backgrounds, as detailed in Table 2, including experts from different academic disciplines across multiple scientific fields, as well as researchers from a public institution specialising in OSH. This scientifically diverse composition aligns with the study’s objectives (Stabile *et al.*, 2025).

Table 2: Multidisciplinary working group

Background	Area of expertise	Focus on the research	Years of experience
Public research	Training and education	Occupational safety and health	26
Public research	Communication and digital technologies	Occupational safety and health	17
Public research	Legal	Occupational safety and health	18
Public research	Psychology	Occupational safety and health	29
Academic/Industrial	Operations management	Manufacturing systems	21
Academic	Smart factories	Manufacturing systems	6
Academic	Advanced industrial applications	Resilience Engineering	4

Source: "Assessing Resilience Practices in the Digital Transformation Era: A Storytelling-Based Cross-Sectional Study in Italy. 2025"

The focus group met for three sessions, each lasting approximately two hours, to discuss and analyse the areas of priority interest.

Structure of the questionnaire

The questionnaire consists of two sections. The first section collects demographic information, including the respondent's role, work experience, and affiliated manufacturing organisation. The second section focuses on processes affected by digital transformation, examining the digital technologies implemented in

the company over the past five years and changes in occupational health and safety training, including methodologies and delivery methods. OSH training, including methodologies and delivery methods. The questionnaire was initially pretested with two manufacturing companies to assess clarity and readability. A focus group of researchers and OSH specialists subsequently conducted a qualitative review, correcting minor errors and inconsistencies and refining the instrument. The questions were then finalised to ensure clarity, comprehensibility, and relevance to the participating companies. While a Cronbach's alpha analysis yielded a reliability score of 0.85, it is important to emphasise that the objective of this study was not to develop a universally generalisable tool. Instead, the questionnaire was designed as a context-specific instrument, tailored to the operational environments of the participating companies, and therefore broader validation was not pursued. The full questionnaire is provided in the Appendix.

Sampling and data collection process

The process of contacting organisations spanned four months, from January to May 2024. Companies were initially contacted by phone and then given the option to complete the questionnaire independently or via a guided phone interview. The process comprised five key stages:

Building contact lists and directories: using the databases "www.registroaziende.it" and www.infocamere.it, companies were filtered by relevant ATECO codes, resulting in 6,400 organisations identified and contacted.

Initial contact: researchers called company secretariats to schedule phone appointments or obtain email addresses, ensuring balanced coverage across Northern, Central, and Southern Italy.

Sending personalized communications: personalized emails,

including an invitation letter, were sent to encourage participation.

Collecting responses: approximately 70% of respondents completed the questionnaire independently via the provided link, while 30% participated in phone interviews lasting 20–30 minutes.

Follow-up: companies that had expressed interest but had not completed the questionnaire within 15 days were re-contacted, with up to three follow-up attempts made.

Data analysis techniques

The data were coded and analysed using IBM SPSS Statistics (version 30.0.0). Descriptive statistics, including frequencies and percentages, were used for data analysis. The Mann–Whitney U Test (McKnight e Najab, 2010), which generalises the Wilcoxon method, was employed to determine significant differences between the distributions of independent groups. This test was considered appropriate as it does not require assumptions about population parameters, and it can be applied when the type of distribution is unknown and when the dependent variable is ordinal. Moreover, if the distribution shape is similar in both groups, the test allows verification of whether there is evidence of a statistically significant difference between the medians of the two groups. The categorical variables used to create the groups were company size and the introduction of new technology over the past five years. A p-value of less than 0.05, with a confidence level of 95%, was considered statistically significant. Broadly interpreted, this study provides a methodological framework that can be applied to similar investigations in different geographical contexts, allowing for comparative analysis across industries and regions.

3. Results

In total, 344 Italian manufacturing companies participated in the survey. The distribution of companies by ATECO code is described in Table 3.

Table 3: Distribution of the company sample by manufacturing ATECO code

ATECO code	**Description**	**% of companies**
10	Manufacture of food products	9,30%
11	Manufacture of beverages	0,29%
13	Manufacture of textile items	2,91%
14	Manufacture of workwear	1,74%
16	Manufacture of wooden containers	8,72%
17	Manufacture of paper and paper products	4,07%
18	Printing and reproduction of recorded media	0,87%
19	Manufacture of coke and refined petroleum products	0,29%
20	Manufacture of chemicals and chemical products	5,81%
22	Manufacture of rubber and plastics products	6,98%
23	Manufacture of other non-metallic mineral products	1,74%
24	Metallurgy	2,33%
25	Manufacture of metal products (excluding machinery and equipment)	12,21%
26	Manufacture of computers, electronics, optics,	6,69%

	electromedical equipment, measuring equipment	
27	Manufacture of electrical and non-electrical household equipment	5,81%
28	Manufacture of machinery and equipment	6,40%
30	Manufacture of other vehicles	1,16%
31	Manufacture of furniture	4,94%
32	Other manufacturing industry	10,76%
33	Repair, maintenance and installation of machinery	0,87%
-	Other (to be specified)	6,10%

Source: FEREO Project 2024

Furthermore, 64,53% of the sample is in Northern Italy, 18,31% in Southern Italy and 17,15% in Central Italy.

In Table 4 the distribution of the sample by firm size is reported.

Table 4: Distribution of the company sample by company size

Company size	**# of companies (%)**
employees <50	59,59%
50< employees <149	26,45%
150< employees <249	5,23%
employees > 250	8,72%

Source: FEREO Project 2024

Most companies are small (59.59%), while 26.45% are medium-small, 5.23% are medium-large and the remaining 8.73% are large companies.

3.1 Analysis of the technologies introduced, actions implemented and process changes

The first variable investigates the digital technologies introduced into the company over the last five years. For simplicity, the innovations have been divided into four macro areas: People Innovation: AR/VR/XR/Smart Wearables/Smart Devices/Exoskeletons; Software Innovation: AI/ML/Deep Learning/Digital Twin/RPA; Working Innovation: Smart Workplace (Smart Working, ERP, CRM, etc.); Innovation in processes: Additive Manufacturing/IIOT/ Robotics. It should be noted that the innovations introduced in companies over the last 5 years (Table 5) concerned working methods in 34% of cases, processes in 18.9%, software in 15.4% and only 4.4% concerned people. It should be noted that 49.1% of the companies surveyed stated that they had not introduced any digital technology in the last 5 years.

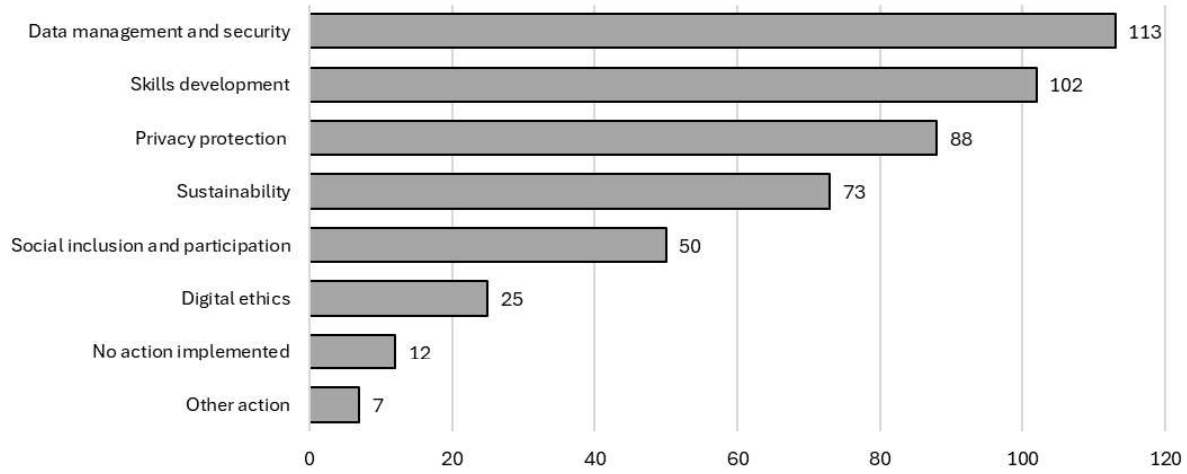
Table 5: Digital technologies introduced in the factory in the last 5 years

Digital technologies introduced in the factory in the last 5 years	**Percentage of total holdings**
People Innovation (AR/VR/XR/Smart Wearable/Smart Devices/Exoskeltons)	4,4
Software innovation (AI/ML/Deep Learning/Digital Twin/RPA)	15,4
Working Innovation (Smart Workplace: Smart Working, ERP, CRM…)	34,3
Process Innovation (Additive Manufacturing/IIOT/Robotics)	18,9
No technology has been introduced	49,1

Source: FEREO Project 2024

The second variable concerns the actions that were implemented following the introduction of the technologies. The histogram is shown below to represent the results (Chart 1).

Chart 1: Actions Implemented in the Company Following the Introduction of Technologies



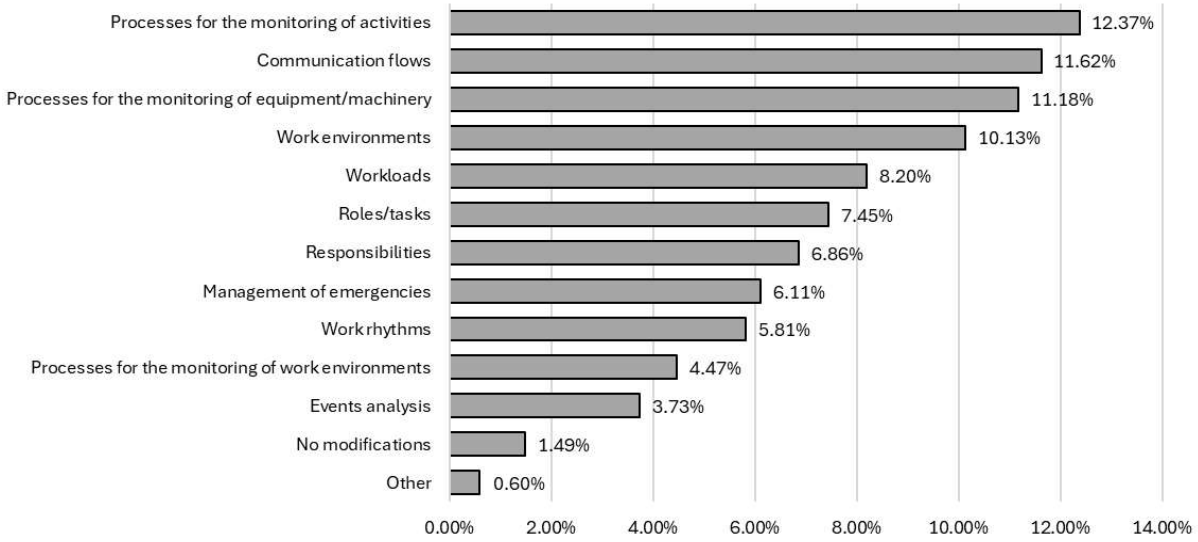
Source: FEREO Project 2024

Among the most common actions are those related to data management and security, skills development, privacy protection and sustainability.

Approximately 40% of companies (i.e. 169 companies) state that no digital technologies have been introduced in the last 5 years.

A further variable in this section collects information on changes made at the organisational level, again following the introduction of technologies (Chart 2).

Chart 2: Changes Implemented in the Company Following the Introduction of Technologies



Source: FEREO Project 2024

The main changes involved monitoring processes in 12.37% of cases, communication flows in 11.62%, equipment and machinery monitoring processes in 11.18%, and work environments in 10.13%, decreasing to event analysis methods in 3.73% of cases. Only 0.6% of respondents reported other types of changes in the "other" category.

3.2 Analysis of Occupational Health and Safety Training

The changes implemented by the company in health and safety training, following the introduction of digital technologies, were also examined. (Table 7).

Table 7: Changes in OSH Training Within the Company Following Technology Implementation

OSH Training	Answer number	Total percentage of responses
Objectives	41	15,02%
Contents	50	18,32%
Methods	68	24,91%
Methodologies	67	24,54%
No changes were made	47	17,22%

Source: FEREO Project 2024

In 17.22% of cases, no changes were made to the OSH training programme. The categories Methods and Methodologies were evenly distributed, accounting for 24.91% and 24.54%, respectively, followed by Content (18.32%) and Objectives (15.02%).

The training methodologies employed by the company in the field of health and safety over the past five years were also examined (Table 8).

Table 8: Company Training Methodologies in Occupational Health and Safety (Last Five Years)

Training methodologies	Answer number	Total percentage of responses
Lectures	232	35,80%
Teacher–learner dialogue and discussion-based lessons	211	32,56%
Virtual simulation activities using technology	20	3,09%
Gamification-based activities	10	1,54%
Practical exercises using technology	46	7,10%

Training methodologies	Answer number	Total percentage of responses
Alternating lessons with exercises and/or simulations	129	19,91%
Other	/	/

Source: FEREO Project 2024

The most commonly used methodologies were traditional lectures (35.8%) and lessons based on teacher–student dialogue and discussion (32.56%). A combination of lessons and exercises and/or simulations was used in 19.91% of cases. Lower prevalence values were observed for more innovative training methods, including practical exercises with physical simulators (7.10%), virtual simulations using virtual or augmented reality (3.09%), and gamification (1.54%).

Finally, the delivery methods for health and safety courses were analysed. The data are presented in Table 9.

Table 9: Occupational Health and Safety Course Delivery Methods

Course delivery methods	Answer number	Total percentage of responses
In-person	284	42,90%
Distance learning (live or recorded self-paced courses)	80	12,08%
E-learning (asynchronous distance learning courses with	113	17,07%

Course delivery methods	Answer number	Total percentage of responses
attendance tracking and tutor support, without simultaneous presence of learners and instructors)		
Synchronous video conferencing (live distance learning courses with real-time interaction between learners and instructors)	97	14,65%
Blended learning (combination of face-to-face and distance learning)	88	13,29%
Other	/	/

Source: FEREO Project 2024

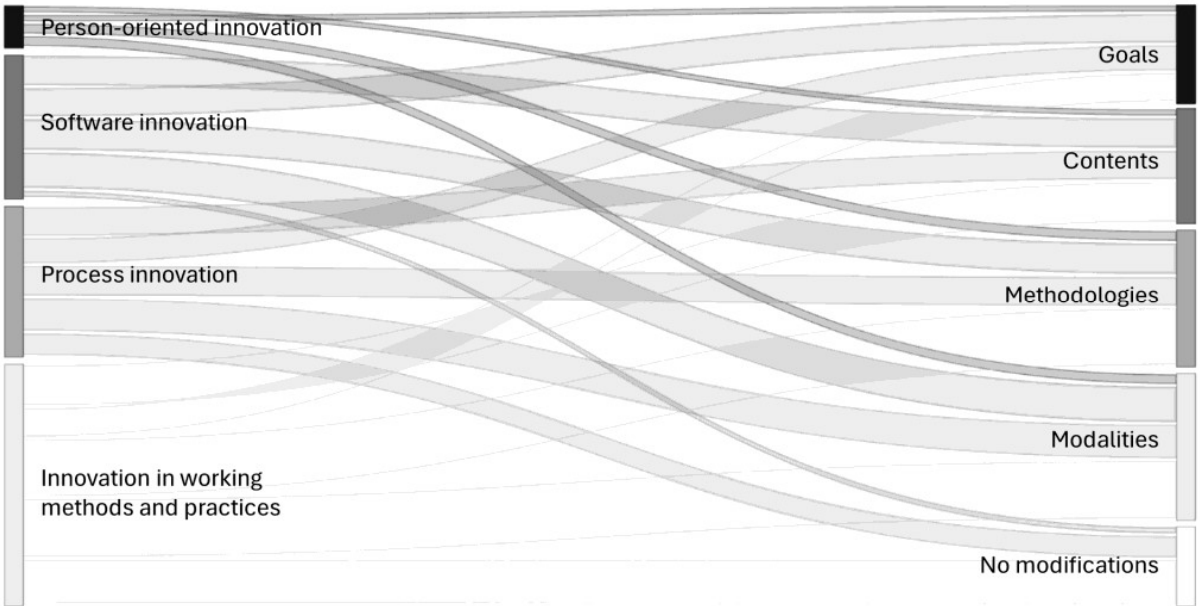
Of the courses, 42.90% were delivered in person, 17.07% via e-learning, 14.65% via synchronous video conferencing, and 13.29% via blended or distance learning.

3.3 Bivariate analysis

The bivariate analyses examined the relationships between variables from the first section – socio-demographic data – and those from the second section – analysis of processes affected by digital transformation, particularly training and skills development as

captured in the administered questionnaire. When comparing the changes made to OSH training following the introduction of technologies, the distribution of innovations across objectives, content, methods, and methodologies was relatively balanced. Methods and methodologies exhibited slightly higher frequencies, while training objectives and content showed slightly lower frequencies.

Chart 3: Frequency and distribution of the changes introduced in OHS training by type of innovation implemented



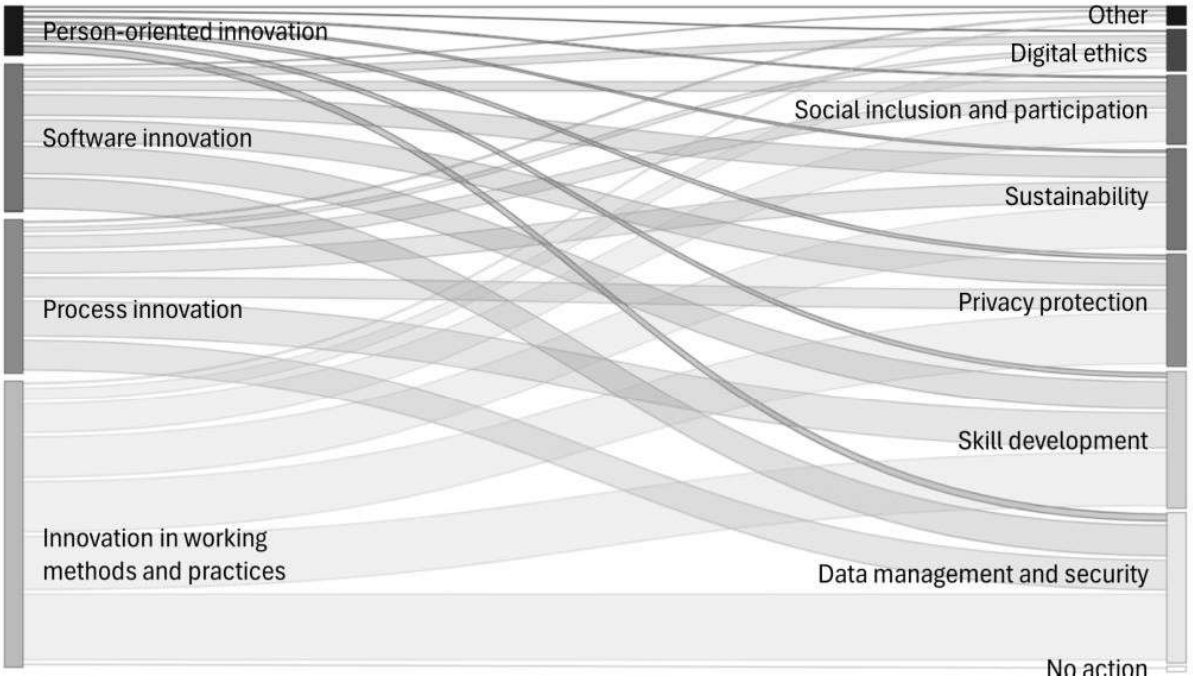
Source: FEREO Project 2024

The heat map presented above illustrates the frequency of various changes made to OSH training following the introduction of technological innovations. As noted, the changes primarily concern training methods and procedures, while other types of changes fall within a mid-range frequency. Unlike the other analyses, a substantial number of cases involved no changes, particularly regarding innovations in working methods.

Furthermore, a comparison of actions implemented in companies

in response to introduced innovations indicates that the highest frequencies occur in the category of innovations in working methods, encompassing data management and security, skills development, and privacy protection. This trend is also observed in the categories of process and software innovation, which appear to introduce similar actions to a comparable extent.

Chart 4: Frequency and distribution of the actions implemented by type of innovation introduced



Source: FEREO Project 2024

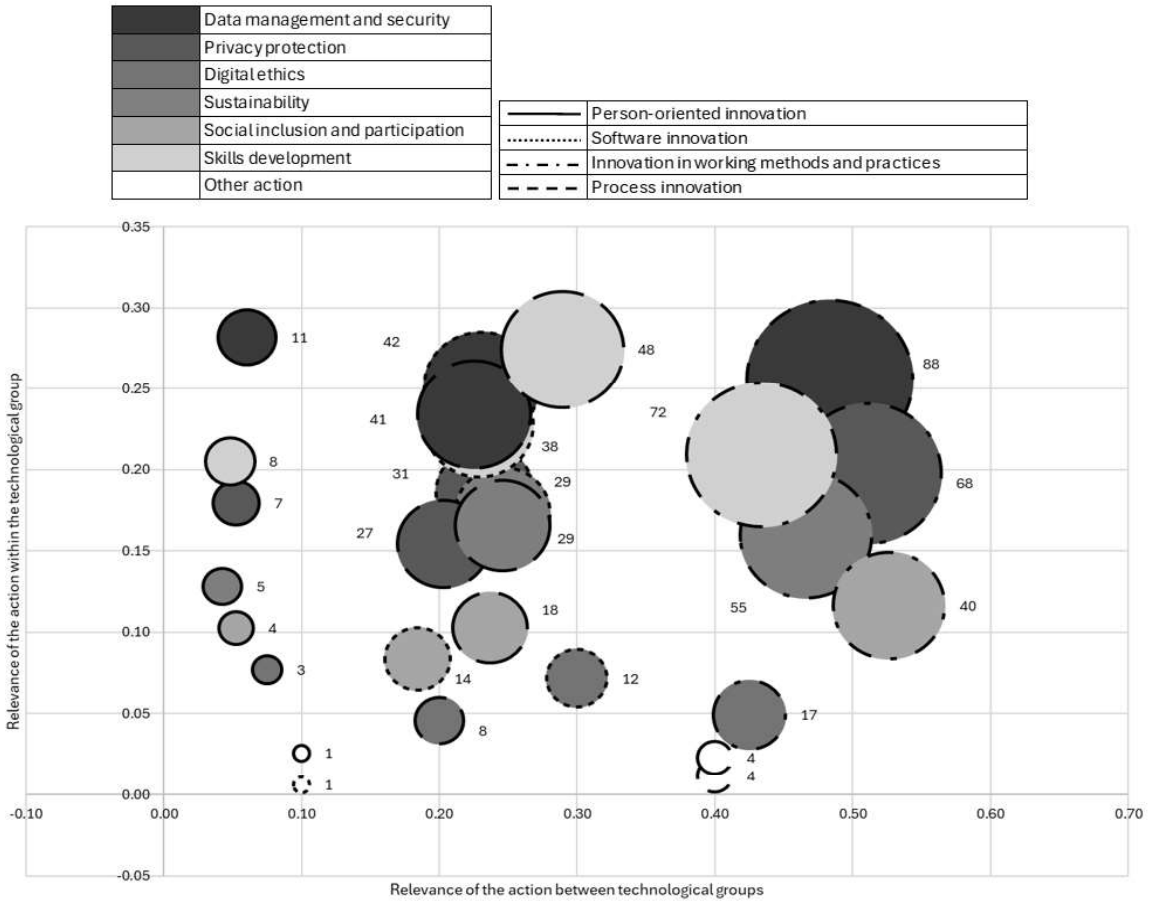
The heat map confirms that actions are primarily concentrated in certain categories, despite the diversity of technological innovations introduced. The following bubble chart provides a more detailed analysis of the actions implemented and the corresponding digital technologies:

- The X-axis represents the relevance of each action across technology groups;

- The Y-axis represents the relevance of each action within a given technology group;
- The outline of the bubbles indicates the type of innovation (people, software, working methods, or processes);
- The colour of the bubbles represents the type of action (data management and security, privacy protection, digital ethics, sustainability, inclusion and participation, skills development, or other actions).

The size of the bubbles reflects the importance of the implemented action.

Chart 5: Frequency and distribution of the actions implemented in relation to the digital technologies introduced



Source: FEREO Project 2024

The larger bubbles are positioned towards the centre-right of the graph, indicating that many actions are of significant relevance both across technology groups and within specific technology groups of interest. These primarily correspond to actions related to data management and security, skills development, privacy protection, and sustainability, and are associated with innovations in working methods. In contrast, smaller bubbles are located on the left and bottom of the graph. Those on the left correspond to innovations related to individuals and show low relevance across groups, while those at the bottom pertain to actions related to inclusion and participation, digital ethics, and other actions, reflecting low relevance within their respective technology groups. Overall, actions involving innovations in working methods appear particularly significant across technology groups, including those related to software innovations. Actions associated with process and people-oriented innovations are more evenly distributed within the group and exhibit lower importance across groups. Notably, the graph reveals emerging clusters: one cluster corresponds to actions within the working methods innovation group, another encompasses software and process innovations, and a final cluster relates to people-oriented innovations. These clusters, differentiated by technology class, highlight variations in the technological maturity of the innovations introduced.

Discussion and conclusion

Our analysis indicates that, while new technologies offer significant advantages, they also present challenges, including the reorganisation of workspaces and schedules and the emergence of new risks associated with digital tools (Costantino *et al.*, 2021; Pietrafesa *et al.*, 2019). These changes increase the demand for

digital and transversal skills, often requiring higher-order cognitive processes (WEF, 2025; Robasto, 2019). Investment in mature technologies is generally considered less risky, as these solutions demonstrate proven effectiveness, reliability, and ease of integration, with costs typically decreasing over time. Accordingly, the companies surveyed tend to adopt well-established technologies rather than emerging ones. When new digital technologies are introduced, company actions primarily focus on data management and security, skills development, privacy protection, and sustainability. Innovations in working methods are the most frequent, followed by process and software innovations, whereas people-focused innovations are less common.

Recent changes in work organisation, particularly the intensification of Smart Workplaces, digital, intelligent, flexible, and adaptable environments integrating multiple technologies, have prompted companies to implement measures ensuring secure and efficient data management. These measures include robust protocols for data access, protection against external threats, privacy protection techniques, and continuous skills development to maintain employee proficiency with new software and technologies tools.

The results of these actions appear consistent with the types of innovation: both skills development and data management and security are prioritised, followed by privacy protection and sustainability. However, the analysis also highlights a limited focus on digital ethics, inclusion, and participation. In this context, OSH training remains an essential component of an effective system for the prevention of accidents and occupational diseases and should be understood as an educational process aimed at enhancing both work quality and production processes. Professional development is increasingly framed within a lifelong learning approach (Robasto, 2019), requiring a differentiated and balanced training programme

throughout an individual's career.

The limited adoption of digital or "Training 4.0" approaches among the surveyed companies may result from technological limitations, a preference for traditional methods, or current legislative constraints, which restrict the use of digital delivery to e-learning and synchronous videoconferencing. At the same time, international evidence shows that digitalisation is reshaping risk profiles, with a growing importance of psychosocial and organisational risks, algorithmic management and constant connectivity. In this context, OSH training should not be confined to the transmission of technical or regulatory knowledge but should also cultivate transversal competences such as critical digital literacy, communication, ethical awareness, and collaborative problem-solving, thereby supporting a genuinely human-centred and inclusive approach to innovation.

As previously noted, the adoption of immersive technologies as instructional tools represents one of the most promising innovations for OSH training introduced under the 2025 State–Regions Agreement. These technologies provide substantial training opportunities, enabling workers to acquire specific competencies, enhance risk awareness, and act more responsibly. Key advantages include the creation of immersive and engaging scenarios, the flexibility and reproducibility of virtual environments, the ability to manage risk situations safely, experiential learning without harmful consequences, the simultaneous training of multiple individuals, and the personalisation of learning pathways according to roles, processes, and individual characteristics. In this way, immersive technologies facilitate experiential learning that is often more impactful than traditional approaches, particularly in complex work environments (Bernabei *et al.*, 2024).

However, these potential benefits are accompanied by considerable challenges. Implementation requires substantial

investments in infrastructure and content, which can be difficult for small enterprises to sustain. Designing realistic scenarios necessitates specialised expertise and a significant allocation of professional resources. From a pedagogical perspective, there is a risk of overemphasising practical experience at the expense of theoretical reflection and regulatory knowledge. Additional limitations include potential physical and cognitive discomfort associated with prolonged headset use, such as cybersickness (ILO, 2025), and the absence of standardised metrics for evaluating training effectiveness. From an organisational perspective, the introduction of such tools necessitates a redefinition of instructional timelines and a renewed role for trainers in managing and supporting learning through these technologies. Training is increasingly recognised as a crucial means of addressing the cultural and operational challenges associated with the evolving world of work. It is therefore essential to plan training activities that not only enhance health and safety conditions but also foster the cognitive and professional development of workers, adopting an innovative approach that reconciles workers' rights and needs with ongoing transitional processes.

Finally, several limitations should be considered when interpreting the study's findings. First, its exclusive focus on Italian companies restricts the generalisability of the results to other geographical or cultural contexts, as OSH practices and technology adoption vary considerably across countries due to differences in regulations, cultures, and contextual factors. Within Italy, the regional and sectoral distribution of participating companies was uneven, with a predominance of responses from Northern Italy and the underrepresentation of certain ATECO manufacturing sectors. Moreover, while the use of questionnaires is practical and efficient, it has inherent limitations. Despite a substantial sample size, responses may have been influenced by social desirability or recall

biases, as respondents might overstate positive behaviours or misremember past events. The study also did not examine sector-specific safety procedures in detail. Given the diversity of sectors included, the granularity of the data was insufficient for detailed comparisons. Safety dynamics and priorities can differ markedly between high-risk industries, such as the chemical or mining sectors, and lower-risk industries, such as services or retail. These aspects were not fully explored, thereby limiting the understanding of safety practices across different contexts. While these limitations do not invalidate the study's findings, they should nonetheless be carefully considered when interpreting the conclusions and their implications for OSH within organisations.

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