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Co-Creating Inclusive Work Environments for People with Disabilities

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Abstract

Workplace inclusion and the sustainable well-being of people with disabilities represent a critical social and technological challenge. This paper presents the exploratory insights of a study aimed at identifying both interaction needs for workplace technologies and socio-organizational conditions that support inclusive and sustainable employment. The study adopts a co-creation methodology based on the Design Thinking approach through the implementation of four co-creation events with workers with disabilities and key stakeholders. The findings reveal persistent barriers at structural, cultural, and operational levels, including the lack of dedicated support roles, limited awareness of disability diversity, and the persistence of non-accessible environments, tools, and work processes. From a technological perspective, the study identifies key interaction needs for inclusive workplace design across five dimensions: usability, accessibility, robustness, accuracy, and personalization. While these requirements manifest differently across disability types, several cross-cutting needs emerge, including accessible and comprehensible information, adaptive and customizable systems, reliable assistive technologies, and inclusive organizational practices. The results conceptualize workplace inclusion as a socio-technical ecosystem in which technological innovation, organizational arrangements, and accessibility culture co-evolve. The paper contributes to research and practice by providing empirically grounded design implications for developing inclusive workplace technologies that promote autonomy, participation, and long-term well-being.

Keywords: workplace inclusion; disability; assistive technologies; participatory methodologies; co-creation; human–machine interaction; user-centred design

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1. Introduction

The inclusion of people with disabilities in the workplace is one of the most important challenges of our society. This aligns with some of the Sustainable Development Goals defined in the 2030 Agenda for Sustainable Development Goals (SDGs) [1]. Specifically, SDG 8—Decent Work and Economic Growth and SDG 10—Reduced Inequalities invite to ensure equitable access and improve inclusion and quality of life in employment for people with disabilities. Despite increased efforts by governments, growing regulatory attention around the world, and advances in assistive technologies, many barriers to workplace inclusion still exist. These barriers are not only technological but also social, organizational, and cultural, affecting the autonomy and well-being of people with disabilities.

Much of the existing literature is fragmented, addressing workplace inclusion, assistive technologies, and well-being as separate domains, with limited integration across

technological, organizational, and experiential dimensions [2–8]. There is a need for more empirical research that analyses the interplay between assistive technologies, leadership, governance, and the well-being of employees with disabilities in an integrated manner [9].

This study addresses these gaps by investigating workplace inclusion as a socio-technical ecosystem that integrates technological, organizational, and social dimensions. The goal is to understand the challenges and needs faced by individuals with disabilities in workplace contexts, focusing not only on the use of digital tools, but also on organisational practices, relationships between work colleagues, and daily processes. At the same time, the study aims to analyse the limitations of currently available technologies, highlighting critical issues and analysing how these limitations affect the work experience. Furthermore, it aims to identify interaction needs with assistive technologies, both transversal and specific to different types of disability, to gain exploratory insights into how interaction requirements differ based on varying conditions and operational contexts.

This study specifically addresses the following research questions:

- What social and organizational challenges affect the workplace inclusion of people with disabilities?
- What limitations and barriers exist in current workplace technologies used by people with disabilities?
- How do human–machine interaction requirements vary among individuals with intellectual, visual, physical, and hearing disabilities in workplace environments? Which requirements are shared across different disability groups?

To address these questions, this study adopts a co-creation methodology based on the Design Thinking approach. This involves the implementation of four co-creation events held in Italy as part of the NewWorkTech project [10]. These events brought together individuals with disabilities and different stakeholders to collaboratively investigate interaction requirements and socio-organizational factors that affect inclusive workplaces.

This study provides exploratory contributions to existing research on inclusive workplace technologies in three complementary ways. First, it provides an empirical contribution by generating systematically collected, cross-disability evidence on interaction needs from four co-creation events involving individuals with intellectual, visual, physical, and hearing impairments. Unlike much of the existing literature, which often focuses on single disability groups or specific assistive tools, this study offers a comparative perspective that highlights both shared and disability-specific requirements across different disabilities. It highlights patterns of convergence as well as divergence based on various contexts of use. Second, it offers a methodological contribution by demonstrating how Design Thinking-based co-creation can be used not only for developing solutions but also as a structured research strategy to gather situated, experience-based knowledge regarding workplace technologies, organizational practices, and everyday interaction challenges. Specifically, the co-creation events make visible the interdependencies between technological constraints and organizational conditions, which are often underexplored in studies that rely solely on usability testing or interviews. Third, the study offers a conceptual contribution by framing workplace inclusion as a socio-technical ecosystem. This framing should be understood primarily as a theoretically informed interpretative lens, grounded in the empirical findings. It emerges from the analysis to explain how interaction needs, technological affordances, organizational arrangements, and cultural factors mutually influence one another and should be addressed in an integrated manner. Together, these contributions offer exploratory insights into the added value of the study in bridging technological, organizational, and experiential perspectives on inclusive workplace design.

This paper is structured as follows: Section 2 provides an overview of the studies on co-creation methods to support workplace inclusion. Section 3 describes the participatory

methodology used in the case study. In Section 4, a discussion on the findings from the four co-creation events is provided. Finally, Section 5 concludes the paper with a discussion on the main results of the work.

2. Related Work

Co-creation has emerged as a key approach in the design of technologies aimed at improving work environments for people with disabilities [11]. By actively involving end users and multiple stakeholders throughout the design process, co-creation enhances the relevance, usability, and ethical legitimacy of technological solutions. In workplace contexts, where accessibility, productivity, and well-being intersect, co-creation methods are increasingly adopted to address diverse functional, cognitive, and sensory needs while accounting for situated work practices.

Within the broad landscape of co-creation, several methods can be identified, differing in terms of participatory depth, scalability, and analytical scope. These include User-Centred Design (UCD) [12], participatory methodologies [13], and Design Thinking [14]. While all share a commitment to user involvement, they vary significantly in how they integrate technological, organizational, and social dimensions.

User-Centred Design (UCD) emphasizes the systematic involvement of end users throughout the design lifecycle to ensure usability, efficiency, and accessibility. In the field of disability, UCD has played a fundamental role in advancing inclusive design by foregrounding user needs and supporting compliance with accessibility standards [12,15]. By centring design decisions on user experience, UCD contributes to the development of accessible and empowering technologies [16]. However, UCD approaches are most often applied to the design or refinement of specific technological artefacts, with limited consideration of broader organizational structures, workplace cultures, and socio-technical dynamics.

Human–machine interaction (HMI) complements UCD by providing theoretical and methodological frameworks to study how users interact with digital systems. Together, UCD and HCI inform interface design, usability evaluation, and accessibility practices, contributing to greater autonomy and employability for people with disabilities [17].

Participatory methodologies extend user involvement by positioning people with disabilities as active partners in the design process, allow focusing on the complex interplay between technology, work organization, and institutional practices [18,19].

Methods such as focus groups, workshops, interviews, surveys, and empathic design have been widely adopted to elicit user needs and experiential knowledge [13,20–22]. These approaches are particularly valuable for surfacing tacit, context-specific insights that may not emerge through conventional usability evaluation. However, participatory methods also present limitations: focus groups may be influenced by group dynamics and dominant voices; interviews and surveys are generally non-interactive and limited to early-stage data collection [23,24]. Similarly, workshops, although effective in fostering collaboration and creativity, are often conducted as isolated events lacking systematic iteration [25,26]. Moreover, empathic design techniques that simulate disability risk oversimplify lived experiences if not grounded in sustained user engagement [27]. Design Thinking emerges as a particularly innovative and suitable approach for addressing the complexity of inclusive workplace design. Design Thinking is a human-centred, iterative methodology specifically oriented toward tackling complex and systemic problems. Unlike other approaches, it offers an end-to-end process that integrates problem framing, empathy building, ideation, prototyping, and testing within a single coherent framework [14]. This holistic structure enables the simultaneous consideration of user needs, technological feasibility, and organizational constraints, making it especially effective for analysing workplace inclusion as a socio-technical phenomenon rather than a purely technological challenge.

A key innovative aspect of Design Thinking lies in its strong emphasis on empathy and iterative sense-making. Continuous engagement with people with disabilities throughout the process allows emergent needs, contextual constraints, and unintended consequences to be identified early and revisited over time [28,29]. This iterative logic supports the progressive refinement of both technological concepts and organizational practices, enabling solutions to evolve in response to real-world feedback [30]. Importantly, Design Thinking facilitates the integration of experiential knowledge with institutional and technical perspectives, fostering shared understanding among heterogeneous stakeholders.

Furthermore, Design Thinking extends beyond the design of individual technologies by explicitly incorporating organizational workflows, roles, and cultural factors into the analysis. This capacity to bridge interaction requirements with social and organizational dimensions represents a significant advancement over approaches supporting not only inclusive technology design but also the co-creation of inclusive workplace ecosystems.

Comparing the three approaches, UCD provides pragmatic and efficient solutions for the development of accessible technologies, while participatory methodologies offer strong user empowerment and rich contextual insights, albeit often at high organizational cost. Design Thinking, although resource-intensive, enhances the validity and systemic impact of innovation by integrating user, technical, and organizational dimensions within a structured and iterative process.

For these reasons, Design Thinking is particularly well-suited to investigate both user interaction requirements for inclusive design and the social and organizational barriers that affect workplace inclusion for people with disabilities, as undertaken in this study. Table 1 provides a comparative overview of the discussed methods.

Table 1. A comparative table of co-creation methods.

Method	Main Focus	Strengths	Limitations
User-Centred Design (UCD)	Usability, efficiency, and accessibility across the system lifecycle.	Systematic and iterative; strong focus on accessibility and standards; effective for technological development.	Often focuses on specific technologies; limited attention to organizational dynamics.
Participatory methodologies	User empowerment and contextual knowledge creation.	High user engagement; surfaces tacit and experiential knowledge; supports inclusion.	Resource-intensive; may lack structured iteration; outcomes depend on facilitation quality.
Design Thinking	Innovation through empathy, iteration, and holistic problem framing.	End-to-end process; integrates user, technical, and organizational dimensions; supports complex workplaces.	Can be resource-intensive; requires careful implementation to ensure inclusion.

3. Methodology

The study adopted a participatory co-creation methodology based on the Design Thinking approach, investigating the needs, challenges, and expectations of people with disabilities in workplace environments. The methodological framework followed an iterative process structured into four phases (i.e., empathy, problem definition, ideation, and prototyping) aimed at identifying both functional and experiential user requirements with technologies as well as social and organizational challenges for workplace inclusion.

In the empathy phase, qualitative insights were collected through a series of meetings with associations representing people with disabilities. These meetings aimed to help us to understand work routines and challenges experienced by people with different types

of disabilities. Furthermore, these associations facilitated the engagement of people with disabilities in an ethical, respectful, and inclusive manner.

These insights informed the problem definition phase, during which eight realistic interaction scenarios were developed to represent workplace contexts. The scenarios were constructed on a combination of empirical inputs gathered during the preliminary meetings with representative associations, evidence from the literature on workplace inclusion and assistive technologies, and the research team's expertise in human–machine interaction and inclusive design. Each scenario depicts a fictional yet plausible user profile engaged in typical work activities, designed to foster empathy and elicit situated reflections during the co-creation process.

The development of the scenarios followed an iterative and participatory approach. Initial drafts were shared and discussed with representatives of associations of people with disabilities, who provided feedback on their realism, clarity, and relevance to actual workplace experiences.

This review process contributed to ensuring that the scenarios accurately reflected a variety of needs, abilities, and contextual constraints, while avoiding stereotypical or oversimplified representations. Following this validation phase, the scenarios were further refined by the research team to improve their accessibility and usability within the co-creation setting. In particular, attention was given to the clarity of language, the level of detail provided, and the alignment between user profiles and the targeted research questions. Minor adjustments were also introduced after internal pilot testing of the workshop materials to ensure that the scenarios were easily understandable and effective in stimulating discussion among participants with different backgrounds.

Each scenario was accompanied by three triggering questions designed to stimulate reflection and discussion about user needs, interaction challenges, and expectations regarding workplace technologies (see Table 2).

Table 2. Summary of Co-creation Interaction Scenarios.

Scenario—Disability Type	User Profile and Work Context	Research Focus
S1 Visual impairment	Elisa is an administrative secretary in a consulting firm responsible for document management, internal communication, and administrative support.	Barriers in using office technologies and potential innovative solutions to improve accessibility and interaction.
S2 Visual impairment	Giulio is a blind secondary school teacher who prepares lessons, teaches, and evaluates students using screen reader technologies.	Usability of assistive technologies in educational environments and improvements for accessible digital interaction.
S3 Intellectual disability	Anna is an office assistant with Down syndrome who supports administrative tasks such as organizing documents, writing emails, and preparing materials for meetings.	Barriers in workplace tasks and technological solutions to simplify workflows and support task execution.
S4 Intellectual disability	Marco is a warehouse worker with Down syndrome in a logistics company responsible for shelving products, scanning barcodes, and preparing shipments.	Difficulties and technologies supporting task comprehension, workflow guidance and operational accuracy.

Table 2. *Cont.*

Scenario—Disability Type	User Profile and Work Context	Research Focus
S5 Physical disability	Luca is an administrative employee in a large company performing document management, communication, and data analysis using collaborative digital tools.	Physical and interaction barriers in workplace technologies and potential innovative solutions.
S6 Physical disability	Sara is a sales assistant in a sporting goods store who uses an electric wheelchair and manages customer assistance and stock through a company tablet.	Accessibility of digital tools and workplace environments for employees with mobility impairments.
S7 Hearing impairment	Stefania is an administrative assistant in a medium-sized company who relies on digital technologies to perform office tasks independently.	Communication barriers and accessibility of workplace technologies for employees with hearing impairments.
S8 Hearing impairment	Paolo is a woodworker in an industrial workshop using machinery for cutting and assembling wood components.	Safety and communication challenges in noisy environments and technological solutions for accessible alerts and signals.

The ideation phase was implemented through structured co-creation events that brought together diverse stakeholders, including people with disabilities, representative associations, technology experts, policymakers, educators, and employment inclusion officers.

Participant recruitment followed a transparent and ethical process to ensure informed and voluntary participation, and only individuals aged 18 and older were eligible to participate. Representative associations facilitated the engagement of people with disabilities in an ethical, respectful, and inclusive manner. The recruitment strategy also aimed to achieve gender balance (approximately 50% male and 50% female). Participants were recruited through both direct contact by researchers, via meetings, email, and phone, and indirect dissemination through social media and institutional networks.

The study was conducted in accordance with relevant ethical standards and applicable data protection regulations. Any identifying personal information collected was used solely to manage registrations for the co-creation events; it was processed separately from the research dataset and remained inaccessible for research purposes, ensuring it could not be linked directly or indirectly to the study's findings.

Before participating, all participants received clear information regarding the aims of the study, the anonymous treatment of data, and their right to withdraw at any time without consequences. Written informed consent was obtained from all participants before data collection and recorded through the EUSurvey platform [31] provided by the European Commission. No clinical, diagnostic, or sensitive health information was collected. Disability-related information was considered only indirectly and at a general level to define the target population and support the interpretation of accessibility and workplace interaction needs. No medical documentation, diagnostic records, or health-status assessments were requested or stored. Data consisted exclusively of anonymous responses generated during the co-creation activities and were analysed only in aggregated form, ensuring that participants could not be re-identified. All data were securely stored, accessible only to the research team, and are not publicly available to further protect participant confidentiality. Four co-creation events, both in person and online via Microsoft Teams [32], were organized in Italy between September and October 2025, each dedicated to a specific

disability type, involving 54 users and stakeholders. The first event, aimed at people with intellectual disabilities, included 15 participants; the second focused on visual impairments (14 participants); the third addressed physical disabilities (10 participants); and the fourth was organized for deaf people (15 participants).

Table 3 illustrates the number of participants by stakeholder category.

Table 3. Number of participants in the co-creation events by stakeholder category.

Participants	Co-Creation Event for People with Intellectual Impairment	Co-Creation Event for People with Visual Impairment	Co-Creation Event for People with Physical Impairment	Co-Creation Event for People with Hearing Impairment
People with disabilities	3	5	4	10
Associations	3	3	2	4
Policymakers	2			
Technology experts	1	1	1	
Educators	2	2		1
Employment inclusion officers	2	1	1	
Disability managers	1	1		
Researchers	1	1	2	

People with disabilities and relevant stakeholders (associations, technology experts, policymakers, educators, and employment inclusion officers) participated together to allow for broad discussion among participants, the emergence of different points of view, and the shared suggestions. Each co-creation event lasted three hours.

Online and in-person participation had the same value and ensured equal opportunities for engagement and contribution. The main difference concerned the logistical organization of the activities. Online participation was arranged to better accommodate specific accessibility needs and to reduce travel-related barriers, while in-person participation allowed participants to attend the events physically at the venue. In both cases, the activities, discussions, and level of involvement were equivalent.

During each event, eight interaction scenarios related to the specific disability (illustrated in Table 2) were presented and explained to ensure shared understanding among participants. The eight scenarios served as a foundation for collaborative discussions to explore user needs and requirements. After each scenario was presented, participants were encouraged to express their needs and perspectives regarding interactions with emerging technologies in the workplace, within each scenario. To start the discussion, the following three triggering questions were used:

- Based on your experience, what difficulties might the person represented in the scenario encounter when using technology at work? Why?
- In your opinion, how could these difficulties be overcome with the help of other innovative technologies?
- In addition to current technologies, which features should devices and/or tools have to improve his/her working experience? What aspects should be enhanced to facilitate interaction with technology?

To promote an inclusive process that allowed all participants to have an equal voice, two moderators facilitated and encouraged equal participation and provided some examples and clarifications to participants if needed. Each response was discussed collectively to clarify meanings, share opinions and suggestions, generate new ideas, and ensure that all voices are heard.

Accessibility was ensured throughout all the events. For people with intellectual disabilities, easy-to-read language was used, and educators from partner associations supported the moderators in facilitating the discussions. For deaf participants, two Italian Sign Language (LIS) interpreters were engaged. The event for people with physical impairments was held online to maximize accessibility and eliminate travel barriers for wheelchair users.

For participants with visual impairments, moderators gave clear verbal descriptions of visual content shared during the sessions. Additional support was also offered whenever needed to ensure full participation in the discussions.

Responses were collected both through the online tool Slido (Version 1.14.2) [33], which allows participants to submit responses online, and orally through moderated group discussions aimed at clarifying perspectives, generating ideas, and fostering inclusive dialogue among stakeholders.

The insights collected during the co-creation sessions were subsequently examined in the prototyping phase, which in this study does not involve the development or testing of concrete artefacts, but rather an analytical synthesis of user requirements and design implications derived from qualitative data.

This phase corresponds to an analytical synthesis of user requirements and design implications, derived from the qualitative material collected during the co-creation sessions.

These insights were then translated into structured interaction requirements and design-oriented specifications, which can inform the future development of inclusive workplace technologies. Consequently, the prototyping phase is considered a conceptual and analytical stage rather than an experimental or evaluative one, aimed at transforming empirical findings into actionable design knowledge, without the creation or validation of functional prototypes.

The analytical synthesis phase described above provides the basis for the results presented in Section 4.3, where empirically derived themes are systematically interpreted and organized into higher-level interaction requirements.

4. Findings from Co-Creation Events

The qualitative dataset consisted of online written responses collected during the participatory sessions through the tool Slido, together with researchers' notes taken during the discussions. These materials were integrated into a single qualitative corpus before analysis. Slido responses were exported in textual form and treated as part of the same dataset. To preserve contextual meaning, Slido data and researchers' notes were initially coded separately and then iteratively compared and merged during later stages of analysis to identify convergences and divergences across data sources.

Data were analysed using an inductive approach. Collected materials were assigned descriptive codes through an open coding process, which was conducted independently by two researchers. The initial coding frameworks were subsequently compared and refined through joint discussions. Disagreements were resolved through consensus, and when necessary, a third researcher acted as mediator to refine category definitions. This iterative process contributed to ensuring consistency and interpretative validity. Codes were progressively grouped into broader themes and ultimately organized into three overarching macro-areas: (i) social and organizational challenges to workplace inclusion, (ii) technological limitations and barriers to participation and inclusion, (iii) interaction needs

of users with different disabilities in workplace environments. These macro-areas were not predefined but emerged inductively from the data, guided by the research questions.

To distinguish disability-specific and cross-disability patterns, codes were labelled according to whether they referred to issues specific to a particular disability group or to themes shared across groups. These distinctions were further refined through constant comparison across cases and iterative team discussions.

In the following sections, we report the analysis, which provides exploratory insights based on qualitative evidence collected during the co-creation process. They are divided into these three macro-analytical areas.

4.1. Social and Organizational Challenges to Workplace Inclusion

The data from the co-creation events highlights how the main challenges for the workplace inclusion of people with disabilities are not solely related to the accessibility and use of technologies, but also to social and organizational factors that affect their effective adoption. These challenges operate at structural, cultural, and operational levels and require a systemic approach. Needs were expressed across all events, both by workers, who generally focused on current issues in their work environment, and by stakeholders who attempted to identify potential solutions and innovations, both in terms of products and processes. First, many companies lack the specialized expertise required to conduct a preliminary functional assessment and to identify, on a case-by-case basis, the most appropriate technological solutions. The lack of key figures, such as a disability manager or professionals capable of guiding technological and training decisions, makes this difficulty systemic.

> *"...In my company, there is a lack of a dedicated professional figure responsible for understanding and addressing the needs of employees with disabilities and identifying the hardware and software solutions that can truly make the work environment accessible...".*

Dependence on informal support networks, such as colleagues, tutors, or family members, represents an additional critical aspect. While these figures play a crucial role in facilitating learning and adaptation to technologies, their support is neither guaranteed nor systematically structured. This makes inclusion fragile as it depends on contingent relationships rather than stable organizational mechanisms, potentially compromising workers' autonomy over the medium to long term. Therefore, the pivotal role of dedicated support figures, such as tutors and job coaches, was strongly emphasized. In particular, during the co-creation event for people with intellectual disabilities, participants repeatedly highlighted the importance of the process tutor.

> *"...Guided onboarding and personalized support are necessary to overcome challenges and integrate workers with disabilities into the company environment..."*

Their absence or insufficient integration into the workplace complicates both job placement and retention. Conversely, when such support is present and active, difficulties associated with technology use are significantly mitigated, confirming that human support is an indispensable component of inclusive socio-technical systems. Furthermore, there is no third-party organization or official register of experts specializing in the workplace inclusion of people with disabilities that coordinate, update, and ensure the quality of training programs and support workers.

Organizations and employers also demonstrate a structural difficulty in recognizing disability as a heterogeneous and dynamic condition, requiring personalized and adaptable solutions over time. Many organizations are unprepared to employ workers with disabilities, lacking both a clear understanding of their abilities and insufficient knowledge of appropriate assistive devices. This lack translates into standardized solutions that do not consider the specific type of disability, the worker's digital skills, or the specific operational

context. Consequently, potentially useful tools are purchased without a true understanding of the worker's individual needs. Furthermore, the risk of acquiring incompatible devices increases as the Italian assistive technology market is limited, and technologies from foreign companies cannot be tested in real environments but only on online trials. This creates the paradox whereby companies invest in aids that remain underutilized or even unusable, fuelling frustration and dependence rather than autonomy.

At the same time, cultural barriers persist, such as prejudice, concern, or hesitation on the part of employers, relational difficulties, and workplace environments that are not always supportive. For example, a participant stated: *"...Employers generally approach people with disabilities with the concern that they may not be able to successfully complete a task...."*. This issue was highlighted mainly during the events involving people with visual disabilities and intellectual disabilities. Mandatory recruitment policies, when not accompanied by organizational change, risk reinforcing stereotypes rather than valuing competencies. There is also a lack of education for employees without disabilities that would enable effective communication of work processes to colleagues with disabilities and, above all, ensure full inclusion within the organization without any form of discrimination. In these contexts, exclusion is not explicit but manifests itself as a loss of autonomy. This has a direct impact not only on productivity but also on the professional recognition and work identity of people with disabilities.

For deaf people, critical issues, for example, concern everyday communication, such as meetings without interpreters, inaccurate captioning, and exclusive reliance on voice calls instead of written messages. Participants also emphasized the need for qualified interpreters in different settings, and the importance of training colleagues and managers in inclusive communication methods, including basic sign language courses and greater linguistic awareness.

A recurrent issue for workers with cognitive disabilities concerns the lack of clarity regarding tasks and priorities. Participants highlighted that the absence of explicit guidance on the sequence of activities, deadlines, and criteria for task completion generates uncertainty, errors, and an increased cognitive load. This challenge is exacerbated in contexts characterized by frequent changes in procedures or tools, which demand constant adaptability without adequate organizational or training support. Another challenge is the management of time and work performance. Several participants reported that the pressure to meet execution deadlines is incompatible with the operational modes of workers with cognitive disabilities. This misalignment affects not only task effectiveness but also psychological well-being, generating anxiety, frustration, and a sense of inadequacy.

A crucial issue concerns daily processes and practices. Inaccessible documents, software designed without universal design criteria, rigid proprietary platforms, and non-inclusive training represent invisible yet pervasive barriers.

A participant highlighted: *"...Most corporate intranets are not accessible, both in terms of access software and content. Furthermore, it's important to make the entire system used by employees accessible, rather than simply looking for specific accessibility software solutions. For example, it's not enough to purchase a scanner with automatic document archiving for people with visual impairments if the associated management software isn't accessible"*.

Furthermore, there is weak enforcement of accessibility regulations and a design of spaces not always oriented toward universal usability. For example, offices, cafeterias, and warehouses should be designed to be accessible to people with visual and physical impairments. A worker reported: *"the internal route to reach the office is difficult to access. There are several unmarked obstacles (steps, closed doors, etc.), and specific signage is lacking"*.

Moreover, in large logistics companies, physical and organizational barriers can create safety risks and require innovative solutions such as indoor navigation systems and digital

mapping to reduce mobility-related difficulties. Accessibility should not be conceived as a response to a contingent need, but rather as a universal design principle [34] for spaces, services, and processes that can be used by the widest possible number of people.

Participants also highlighted training as a crucial organizational lever. It is not just about training workers with disabilities in the use of aids, but also about disseminating basic accessibility skills to all staff. Knowing how to create an accessible document, to structure a presentation that is understandable even without visual aids, or to properly use assistive technologies in shared workflows should become a collective responsibility. Without this vision, inclusion remains confined to individual solutions and never becomes a quality of the organizational system.

Several critical issues have emerged regarding the topic of non-inclusive training, in particular during the co-creation events for people with visual and hearing impairments. It was reported that *"...training materials presented in training courses sometimes fail to meet accessibility criteria, and the platforms for mandatory distance learning are inaccessible. Sometimes, within the same website, some sections are accessible, but the navigation path to get to that section is not..."*.

From a social perspective, a tension between innovation and trust also emerges. Advanced technologies, including artificial intelligence, wearable devices, and indoor navigation systems, arouse interest and expectations, but also fears related to cognitive noise, poor precision, false positives, and information overload. This highlights a significant organizational challenge: not all innovations automatically improve the work experience. Without the direct involvement of people with disabilities in co-design, testing, and real-world adaptation, the risk is that technologies will increase complexity rather than reduce it.

4.2. Technological Barriers to Participation and Inclusion

Alongside social and organizational challenges, the co-creation process has highlighted several technological barriers and limitations in existing technologies that hinder the work experience of people with disabilities.

It became evident that the technologies currently in use do not always enable workers to effectively operate software or hardware devices. Across all disability categories, a common concern is the excessive complexity of systems and technologies that support work activities, which often include too many functionalities. Many workers are capable of performing their tasks but lack the appropriate tools to do so. This problem is further exacerbated by inadequate training support within organizations. Another significant issue is the management of environments that do not comply with recognized accessibility standards. Common problems include interfaces with crowded icons, small targets, unintuitive layouts, and limited customization options for colours, icon sizes, and text sizes. These challenges are particularly evident in specialized software applications, such as accounting or warehouse management systems.

When analysing issues related to specific disabilities, workers with hearing impairment reported that many training resources used in organizations lack subtitles, making them inaccessible. When subtitles are available, they are often poorly aligned with the spoken content. Furthermore, the absence of Italian Sign Language (LIS) interpretation services at many corporate events has been highlighted as a concern. For individuals with cognitive disabilities, there is a significant lack of systems that can convert on-screen text into "easy-to-read" formats, which would help make content more comprehensible.

For people with visual impairment, the format of digital content presents a significant challenge. Unstructured PDF documents, presentations that use images without descriptions, and educational materials that do not include text alternatives are common barriers. Even though there are technologies available that can convert or describe this

content, their effectiveness is often hindered by problems related to accuracy, reliability, and cognitive overload.

There is still substantial work to be done in the field of accessibility. A common issue is the inconsistency of systems: a device may be accessible, but its accompanying software might not provide accessible interaction modes, limiting the effective use of the tool. A major concern is that commercial software is often unable to be modified to meet the needs of workers with disabilities, due to proprietary limitations, such as fixed zoom functions. They may also be partially or totally incompatible with screen readers, Braille displays, or magnification systems, compromising core activities such as document management. Furthermore, the availability of accessible software solutions in the market remains minimal. The reported critical issues primarily focus on the inability of devices to function effectively in non-optimal conditions, such as limited mobility, constrained posture, or lack of network connectivity—situations that are particularly likely to arise during emergencies. Additionally, for a system to be considered robust, it must include error prevention mechanisms, such as informative messages that confirm whether a procedure has been completed or interrupted and clearly indicate the type of error that occurred using unambiguous and understandable language.

The identified problems affect devices that use algorithms to detect obstacles and barriers in the environments navigated by workers. A notable example discussed during the events is "smart canes," which often generate numerous false positives in their obstacle detection systems. These canes may vibrate continuously, even when there are no obstacles present.

Another example is indoor navigation systems, which primarily struggle with the accuracy of satellite-based positioning. Indoors, this accuracy is typically limited to about three meters, which is insufficient to guarantee safety. For instance, a person with visual impairments could fall down a staircase if the navigation system incorrectly indicates that the area corresponds to a doorway leading into a room.

Commonly raised issues include the inability of technologies to adapt to specific needs and disabilities. Many tools cannot be customized in terms of their hardware or software settings. As mentioned earlier, commercial software often restricts modifications to proprietary code, which significantly limits personalization options. This is especially important for wearable technologies, where a lack of precision or excessive intrusiveness can lead to distrust and rejection by users.

The lack of customization in workstations significantly impacts workers with disabilities, because this lack does not support them in performing operational tasks and assigned procedures. One major issue is the design of the workstations themselves. Workers with physical impairments have expressed concerns about the placement of certain devices and the arrangement of products in warehouses. For instance, they have noted that shelves are often too high and difficult to reach, printers are placed too far from computers, and scanners are oversized for their upper limb capabilities. These challenges are closely tied to the fact that many corporate workflows still depend heavily on paper-based documentation. This reliance creates significant problems for those who cannot lift heavy items or read documents accurately. To address these issues, there is a need to fully digitize procedures and information flows and to provide workers with appropriate and accessible devices. Additionally, workers with visual impairments have emphasized the necessity of "paperless" procedures, as they prefer accessing data on enlarged screens rather than using printed materials.

Issues related to robustness and safety were notably significant for workers with hearing disabilities. Participants reported challenges in recognizing emergencies, such as fires or earthquakes, when alerts relied exclusively on auditory signals. In chaotic

or high-risk environments, the lack of accessible alert mechanisms significantly increases vulnerability. These findings highlight the necessity for emergency systems that incorporate visual and vibratory alerts, ensuring reliable and redundant communication channels under dynamic and safety-critical conditions.

4.3. Emerging Interaction Needs by Disability Type

This section presents a conceptual synthesis generating exploratory insights into user needs and design implications, based on the thematic analysis of contributions from co-creation participants. It translates the qualitative data collected into structured interaction requirements. Therefore, the findings presented here should be understood as design-oriented abstractions grounded in empirical data, rather than as outputs of prototype testing. Additionally, this section interprets the empirical material gathered during the co-creation events to identify key interaction needs related to the use of workplace technologies by individuals with different disabilities. The analysis focuses on how these needs manifest across disability types while also identifying shared design principles that can support the development of an inclusive system.

User requirements were gathered from participants' contributions during discussions and through Slido inputs. These contributions were then compared and grouped iteratively into five analytical dimensions derived from established human–machine interaction and accessibility research. These dimensions typically distinguish between qualities such as usability and accessibility, as well as system-level attributes like robustness, accuracy, and adaptability.

These dimensions serve as analytical tools designed to organize and compare results, rather than as categories that are predetermined before analysing the data. The ordering of these dimensions in the following discussion has been introduced ex post to improve clarity and facilitate comparisons across different disabilities.

For workers with intellectual disabilities, their interaction needs are largely focused on managing cognitive load, understanding tasks, and receiving execution support. Participants reported experiencing difficulties in remembering task sequences, prioritizing activities, and interpreting written instructions, especially in environments where procedures frequently change. These challenges lead to usability needs centred on simplification and guidance, such as step-by-step workflows, reduced interface complexity, and the incorporation of external cognitive supports (e.g., reminders and checklists). Accessibility requirements involve transforming information into formats that are easy to understand, including clear text, multimodal representations, and speech-based assistance. Robustness is highlighted as a critical requirement due to the risk of cognitive breakdowns during task execution. This emphasizes the importance of systems that can support error recovery, maintain task continuity, and provide ongoing guidance. Accuracy is closely related to preventing errors, with participants stressing the necessity for tools that minimize mistakes (e.g., automatic corrections and guided input mechanisms). Lastly, personalization emerges as a key dimension, reflecting the diversity of cognitive profiles and the need for systems that can adapt to individual learning paces, comprehension levels, and task complexities.

The interaction needs of workers with visual impairments are closely linked to their access to digital content and the compatibility of that content with assistive technologies. Participants highlighted ongoing barriers such as inaccessible software, poorly structured documents (like PDFs), and a lack of semantic organization in digital interfaces. Usability challenges arise from the need for consistent interaction methods and navigable structures. Accessibility requirements have been discussed on a wide range of assistive solutions, including screen readers, magnification tools, Braille displays, tactile interfaces, and AI-based image descriptions. Robustness is crucial to ensure that assistive technologies work reliably

across different systems and contexts, especially given the frequent incompatibilities between software and accessibility tools. Accuracy is essential for the correct interpretation of visual information, particularly in automated descriptions or navigation systems, as errors can lead to misunderstandings or safety risks. Personalization is also essential due to the diverse nature of visual impairments, requiring users to have fine-grained control over settings such as contrast, magnification, reading modes, and device configurations.

For workers with physical disabilities, interaction needs are influenced by limitations in motor capabilities and physical access to devices and environments. Participants pointed out challenges not only in software interactions but also in the physical arrangement of workstations and tools. Usability requirements emphasize reducing physical effort by incorporating alternative input methods, such as voice control, switches, or eye-tracking. Additionally, the interface should be designed to minimize the need for precise or repetitive movements. Accessibility involves ensuring that both hardware and software can be operable under conditions of limited or variable motor control, consistent with barrier-free design principles. Robustness is linked to the reliability and physical manageability of assistive devices, which must be stable, durable, and adaptable to different contexts. Accuracy pertains to the system's ability to correctly interpret non-standard or imprecise input signals, particularly in adaptive or assistive control systems. Personalization is especially important due to the diversity of physical impairments, necessitating individualized configurations of both physical setups and digital interfaces.

Workers with hearing impairments primarily need accessible communication and real-time information. Participants reported significant challenges in environments that rely heavily on auditory communication, including meetings, training sessions, and emergencies. Therefore, usability requirements emphasize the importance of providing visual or text-based communication channels as alternatives to auditory interaction. Accessibility focuses on tools like real-time captioning, sign language interpretation, and visual or haptic alert systems, ensuring that information is available across multiple modalities. Robustness is essential for systems used in real-time or safety-critical situations, particularly for captioning and alert mechanisms, which must remain reliable even in dynamic environments. Accuracy represents a key concern, as errors in speech-to-text transcription or sign-language translation can hinder understanding and trust. Personalization is also important, reflecting the diversity of hearing conditions and user preferences. This requires adaptable settings for caption speed, notification modes, vibration intensity, and communication formats. Additionally, participants emphasized the significance of organizational factors, such as training and awareness, in achieving effective communication accessibility.

Table 4 provides a comparative synthesis of user needs across intellectual, visual, physical, and hearing disabilities, organized by key design dimensions (usability, accessibility, robustness, accuracy, and personalization).

Table 4. Comparative table of needs by disability class.

	Intellectual Disabilities	**Visual Disabilities**	**Physical Disabilities**	**Hearing Disabilities**
Usability	Requirement for simplified user interfaces that minimise cognitive load and support guided, step-by-step task execution.	Requirement for consistent, logically structured interaction paradigms and full compatibility with assistive technologies.	Requirement for low-effort interaction mechanisms and alternative input modalities (e.g., voice control, eye tracking).	Requirement for visual or textual substitutes for auditory feedback and support for non-auditory communication channels.

Table 4. *Cont.*

	Intellectual Disabilities	Visual Disabilities	Physical Disabilities	Hearing Disabilities
Accessibility	Requirement for transforming information into highly comprehensible formats, including easy-to-read text, speech-to-text, and multimodal representations.	Requirement for comprehensive support for screen readers, Braille displays, tactile interfaces, and AI-based image description systems.	Requirement for hardware and software systems operable under conditions of limited or imprecise motor control.	Requirement for real-time captioning, sign language interpretation, and visual or haptic alert mechanisms.
Robustness	Requirement for system-level support for error prevention, recovery, and task guidance through intelligent assistance.	Requirement that assistive technologies remain stable and interoperable across heterogeneous software and hardware environments.	Requirement for assistive devices that are physically manageable, durable, and reliable in everyday contexts.	Requirement for captioning and alert systems that remain reliable in dynamic, real-time, or safety-critical situations.
Accuracy	Requirement for consistent and predictable system behaviour to avoid cognitive overload or confusion.	Requirement for precise semantic interpretation of visual information, including images, layout, and navigation cues.	Requirement for adaptive systems capable of accurately interpreting noisy or atypical motor input signals.	Requirement for high levels of accuracy in speech-to-text systems and automated sign-language translation.
Personalization	Requirement for adaptive systems capable of responding to individual cognitive profiles and learning trajectories.	Requirement for fine-grained customization of magnification, contrast, reading modalities, and device configurations.	Requirement for individualized configuration of both assistive hardware and adaptive software solutions.	Requirement for user-controlled personalization of caption timing, visual alerts, vibration intensity, and sign-language preferences.

Despite some differences, several common needs emerged, including accessible information, personalized configurations, reliable assistive systems, and supportive organizational practices.

A cross-disability comparison was conducted to identify both shared and divergent interaction needs. This process followed a constant comparison logic, in which themes emerging in each disability group were systematically contrasted and aligned.

Usability challenges differ by disability, such as cognitive load for intellectual disabilities, interface structure for visual impairments, physical interaction for physical impairments, and communication modality for hearing impairments.

Accessibility emerges as the strongest cross-cutting requirement, though its expression varies: easy-to-read formats for intellectual disabilities, multimodal content for visual impairments, ergonomic access for physical disabilities, and communication accessibility for hearing impairments.

Robustness is universally required because assistive systems must compensate for increased vulnerability to breakdowns, whether cognitive, sensory, or physical. Accuracy

is essential across all groups, but the type of precision needed—semantic, navigational, motor, or linguistic—differs substantially.

Personalization is the unifying principle across all disability categories, reflecting the heterogeneity within each group and the scientific consensus that adaptive, user-centred systems are necessary for equitable workplace participation.

While Table 4 represents a conceptual abstraction of empirically grounded insights, elaborated from raw data, Table 5 was developed through a further level of abstraction aimed at distinguishing between cross-cutting needs, recurring across all disability groups (e.g., simplicity, reliability, configurability) and disability-specific needs, linked to particular sensory, cognitive, or physical conditions.

Table 5. Comparative table on common needs and disability-specific needs to support inclusive and adaptive system design.

	Common	Disability-Specific
Usability	simplicity, consistency, and reduced interaction effort	modality-dependent interaction strategies
Accessibility	barrier-free access to information and services	sensory- or motor-specific access technologies
Robustness	system reliability and fault tolerance	context-dependent robustness requirements (e.g., safety-critical alerts)
Accuracy	minimisation of system errors	domain-specific accuracy constraints (e.g., semantic vs. motor interpretation)
Personalization	user-centred configurability	degree and dimension of personalization linked to disability type

This involved identifying patterns of convergence and divergence across the dataset and synthesizing them into a compact framework highlighting both shared design principles and context-dependent requirements.

Table 5 reveals that, despite important differences, several interaction needs are shared across disability types. Accessible and comprehensible information, system reliability, and the ability to adapt technologies to individual users emerge as core principles of inclusive design. At the same time, each disability group exhibits distinct configurations of needs, reflecting different relationships between users, technologies, and work environments.

Overall, the exploratory insights underscore the importance of designing workplace technologies as flexible, context-aware, and adaptive systems, capable of accommodating both common usability principles and highly specific user requirements.

5. Discussion and Conclusions

The main contribution of this study lies in its provision of exploratory insights through an integrated perspective on workplace inclusion as a socio-technical ecosystem. By combining co-creation methods with a structured analysis of interaction requirements and organizational conditions, the study moves beyond technology-centred approaches and demonstrates how inclusion emerges from the alignment of adaptive technologies, organizational practices, and an accessibility culture. This perspective addresses a gap in existing literature, which often examines technological, social, or organizational dimensions in isolation.

This study presents exploratory insights from four co-creation events using the Design Thinking approach to systematically collect and analyse user interaction needs alongside social and organizational factors affecting the well-being of people with disabilities in the workplace. Through an iterative process structured around four phases (Empathize, Define, Ideate, Prototype), the active involvement of people with disabilities, their representative associations, institutional stakeholders, and technical experts was ensured. By facilitating open dialogue and iterative feedback loops, the diverse users' needs, expectations, and opportunities were explored.

Findings suggest, from an exploratory perspective, that workplace inclusion of people with disabilities cannot be addressed solely through the adoption of assistive technologies, but requires a systemic approach that integrates social, cultural, and organizational dimensions. The main challenges emerge at the structural level (lack of specialized expertise and dedicated roles, such as disability managers), the cultural level (prejudice and limited awareness of disability as a dynamic and heterogeneous condition), and the operational level (processes, tools, and environments not designed according to universal accessibility principles [34]). Standardized solutions, insufficient training, and reliance on informal support networks often undermine autonomy and long-term inclusion. Dedicated support roles, such as tutors and job coaches, along with organization-wide accessibility training, emerge as critical enablers.

This study provides exploratory insights into how inclusive workplace technologies should be designed to address both disability-specific and cross-disability needs. Across all disability groups, participants identified significant barriers to interacting with workplace technologies. Intellectual disabilities were associated with challenges in memory, task sequencing, and comprehension; visual disabilities with inaccessible software and document formats; physical disabilities with limited motor access to devices and environments; and hearing disabilities with communication barriers and insufficient captioning or sign-language support. Although each disability group exhibits distinct patterns of interaction issues, several cross-cutting issues emerge, including the need for accessible information, adaptive systems, reliable assistive technologies, and inclusive organizational practices. These user-reported needs provide empirically grounded requirements and design implications that can guide the design and future testing of inclusive workplace technologies that support autonomy, efficiency, and inclusive participation, highlight potential opportunities for innovation in intelligent assistants, multimodal interfaces [35], adaptive training systems, and accessible digital content.

A cross-cutting expectation, however, concerns a shift in the design paradigm. This study highlights the need to promote a culture of inclusion that redefines accessibility not as an "on-demand" intervention, but as a universal design principle embedded in spaces, services, and processes. From this perspective, the future development of inclusive technologies should be accompanied by organizational models capable of systematically addressing emerging needs, updating professional skills, and aligning technological developments with working practices. Workplace inclusion, therefore, can be interpreted as the result of a socio-technical ecosystem, in which technological innovation, work organization, and accessibility culture must co-evolve. This synergy highlights the profound cultural and organizational shift necessary to transform inclusion from a formal policy into an effective daily practice.

Future research should explore how workplace technologies could integrate adaptive cognitive support, multimodal accessibility features, ergonomic interaction models, and real-time communication tools, and should assess their effectiveness through empirical validation in real-world settings. Specifically, research should explore AI-driven personalization, cross-platform assistive technology compatibility, and organizational strategies that

complement technological interventions. The obtained findings offer exploratory insights and empirically grounded requirements, highlighting potential strategies for the design of inclusive workplace technologies.

They highlight potential strategies to improve autonomy, productivity, and well-being for workers with diverse abilities. These insights should be interpreted as exploratory and grounded in qualitative evidence gathered from the four co-creation events that capture needs and perspectives reported by the users.

Despite its contributions, this study has some limitations related to sample size and composition, which may not fully represent the wide heterogeneity of disability conditions and workplace contexts. While the findings are rich in depth, they may limit generalizability. In addition, the results reflect specific organizational and cultural settings and may not be directly transferable to other contexts. Future research will address these limitations by conducting a comparative study in other European countries with larger and more diverse user groups to validate these requirements across different geographic contexts, organizational settings, and disability groups, and to assess their applicability in the design and evaluation of concrete technological solutions.

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Institutional Review Board Statement: The study was conducted in accordance with relevant ethical standards and applicable data protection regulations. Any identifying personal information collected was used solely to manage registrations for the co-creation events; it was processed separately from the research dataset and remained inaccessible for research purposes, ensuring it could not be linked directly or indirectly to the study's findings. The study did not include clinical intervention, biomedical experimentation, or the collection of sensitive health data. All research data were collected and analysed in a fully anonymous and aggregated form. Written informed consent was obtained from all participants before data collection through the EU Survey platform provided by the European Commission. According to Regulation (EU) 2016/679 (GDPR), Italian Legislative Decree No. 196/2003, as amended by Legislative Decree No. 101/2018, formal Ethics Committee/Institutional Review Board approval was not required for this minimal-risk study based exclusively on anonymous and non-identifiable data. The research was conducted in accordance with the Ethical Charter on Social Sciences and Humanities Research (2017) established by the CNR Research Ethics and Integrity Committee (www.cnr.it/it/ethics, accessed on 24 April 2026).

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