Reframing Success in Embodied Work

Competing Perspectives on Occupational Exoskeleton Adoption

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Abstract

Technology adoption is often framed in binary terms of acceptance or resistance, oversimplifying the complex dynamics of workplace integration. This study introduces the Normalisation-Situated Practice Matrix (NSPM), an analytical heuristic that maps the degree of organisational embedding (normalisation) against the degree of experiential user engagement (situated practice), providing a new way to understand how different stakeholders negotiate the deployment of new technologies. Focusing on occupational exoskeletons in a warehouse setting and drawing on observational fieldwork and 34 semi-structured interviews with frontline employees, managers, and technical and academic experts, this study explores the competing goals, approaches, and lived experiences of these diverse groups.

Our thematic analysis identifies three key dynamics: (1) a disconnect between managerial decisions and employee work realities, pointing to the challenges of top-down implementation; (2) the active role of employees in adapting technology through informal, practice-based strategies that operate alongside official guidelines; and (3) the existence of competing narratives around exoskeleton use that reflect broader organisational tensions, where decision-making authority is concentrated at the executive level while frontline workers bear the embodied consequences. Rather than defining success solely through implementation efficiency or binary adoption metrics, our study demonstrates that technology adoption is a dynamic and contested process shaped by power relations, situated practices, and multiple stakeholder perspectives. The NSPM structures examination of these complexities and reframes success in human-centric terms, offering a diagnostic tool applicable across diverse technology integration contexts.

Keywords: narratives of success, occupational exoskeletons, organisational dynamics, participatory processes, workplace technology adoption

Introduction

The increasing adoption of digital and automated technologies is reshaping workplace environments across industries (Sanyal & Kumar, 2025; Oeij et al., 2019). This study starts from the premise that to successfully integrate embodied, physical workplace technologies like occupational exoskeletons, we need a broader, human-centric perspective that aligns organisational goals with lived, situated experiences. While technological innovations promise reduced workload (Galiano et al., 2024), safer working environments (Ghobakhloo et al., 2023), and more efficient operations (Santa et al., 2013), integrating new technologies into complex, real-world settings is rarely straightforward. As organisations increasingly rely on emerging technologies to drive productivity, safety, and competitive advantage (Leesakul et al., 2022), success cannot be defined solely by functionality or performance metrics but by how technologies are interpreted and negotiated by stakeholders.

Existing research tends to prioritise managerial viewpoints, emphasising efficiency gains and safety measures (Lamberti et al., 2017; Jiao & Zhao, 2014). Additionally, emerging technologies are frequently evaluated using approaches that categorise technology adoption outcomes as acceptance or rejection (Molino et al., 2021; Bhattacherjee & Hikmet, 2007; Donmez-Turan, 2019). While providing high-level insights, this narrowed focus and binary lens overlook the nuanced, everyday interactions between users and technology. Recent studies indicate that successful technology adoption requires managing interactions among various stakeholders and creating environments that foster trust and employee participation (Oeij et al., 2021) and depends not only on technical performance but also on the interplay between employee engagement and organisational culture (Oeij et al., 2022), particularly in industries like logistics, where new technologies directly reshape physical work practices.

Building on this understanding, this study draws upon key concepts from science and technology studies (STS), organisational communication, and the sociology of work, specifically the concepts of normalisation and situated practice. *Normalisation* refers to how tools become embedded and taken for granted within everyday routines (May & Finch, 2009; Murray et al., 2010), while *situated practices* highlight how technologies are adapted, resisted, or reinterpreted in specific organisational contexts (Lave & Wenger, 1991). Existing frameworks tend to address these dimensions separately: Normalisation Process Theory (NPT) provides an account of institutional embedding mechanisms (May & Finch, 2009), but underspecifies how users adapt technologies in practice. Meanwhile, practice-based approaches foreground user agency and contextual adaptation (Suchman, 1987) but often lack systematic attention to the organisational structures within which practices unfold. By combining these perspectives through a proposed Normalisation-Situated Practice Matrix, this study makes misalignment between these dimensions analytically visible: it enables the identification of cases where formal organisational embedding and experiential user engagement diverge. This capacity to diagnose non-alignment is the matrix's distinctive contribution. It reveals, for instance, how high formal integration can coexist with low experiential adaptation or how strong situated engagement can emerge despite limited

organisational support. The matrix is designed to: (1) identify the alignment between user engagement and organisational embedding, (2) diagnose adoption challenges in context, and (3) support adaptive, human-centred integration strategies.

Occupational exoskeletons serve as an ideal case for exploring these dynamics. Designed to reduce physical strain and improve employee well-being, these wearable devices are uniquely positioned to reveal the tensions and complexities of technology integration by intersecting productivity goals with employees' bodily experiences (Bogue, 2018; De Looze et al., 2016). Unlike software or digital tools, exoskeletons directly reshape physical routines and embodied work, making the processes of user adaptation, resistance, and creative appropriation particularly visible. Their success depends on how well the technology is fitted to the real conditions of use, and moreover, is highly dependent on employees' willingness, capacity, and active participation in integrating devices into their daily physical routines.

To address these gaps, this study reframes successful occupational exoskeleton adoption as a situated, iterative process, examining how normalisation and situated practice shape technology integration. The following research question guides the inquiry: *How do normalisation processes and situated practices interact across stakeholder groups to shape the adoption of occupational exoskeletons in warehouse settings?* The research reveals how alignment between organisational perspectives, material conditions, and user adaptations determines what constitutes meaningful integration success, challenging approaches that prioritise formal processes over emergent practice.

To facilitate technology integration in the workplace, we propose the *Normalisation-Situated Practice Matrix* as an analytical heuristic that captures both organisational support and users' situated, adaptive practices. The matrix is neither a universal theory of adoption nor merely a coding scheme; it structures empirical inquiry into the relationship between formal embedding and experiential engagement within specific organisational contexts. The matrix highlights that (1) frontline employees actively co-construct technology use; (2) success is context-dependent and shaped by lived, embodied practice; and (3) technology integration involves ongoing negotiation rather than linear rollout. These findings challenge traditional success metrics, such as adoption rates or user satisfaction scores, and contribute to the development of more inclusive integration strategies that recognise employees as active participants in, rather than passive recipients of, organisational decisions. By expanding existing technology adoption understandings to incorporate relational, experiential, and contested dimensions through a human-centric approach, the matrix can help promote inclusive design and policy decisions (Pasmore et al., 2019). This suggests that, rather than applying universal implementation strategies, technology adoption regulations should allow for gradual familiarisation processes and employee autonomy in adaptation strategies.

Overall, our study makes three interconnected contributions to workplace innovation literature. Conceptually, it combines normalisation theory and situated practice perspectives to create an integrated analytical approach that reveals the relationships and discrepancies

between formal embedding and experiential engagement. Empirically, it provides an in-depth examination of embodied technology adoption through the case of occupational exoskeletons in warehouse settings. Methodologically, it demonstrates how the Normalisation-Situated Practice Matrix can serve as both a diagnostic and strategic tool applicable to different stakeholder perspectives. Rather than prescribing specific implementation protocols, this article offers a flexible analytical model for analysing context-specific adoption dynamics and identifies key leverage points for human-centric integration strategies.

Theoretical framework

Normalisation and situated practice

Science and Technology Studies (STS) has long challenged techno-deterministic adoption narratives. The integration of emerging technologies into organisational life is neither a straightforward technical implementation nor a simple function of managerial will; it is a socially embedded process shaped by institutional logics and the lived realities of users (Suchman, 1987; Orlikowski, 2007).

To develop a context-sensitive understanding of technological integration, we focus on two complementary concepts: normalisation and situated practice. Each offers critical insights into the integration process; however, focusing on one exclusively risks either overstating the coherence of organisational adoption or underestimating the structural conditions that shape individual engagement. These concepts are synthesised here in our Normalisation-Situated Practice Matrix, a tool for mapping the divergences between policy and practice, system and experience, and intended and emergent outcomes.

Normalisation: Embedding technology in organisational practice

Normalisation provides an understanding of how new technologies become embedded in routine practice. At its core, normalisation refers to the institutional embedding of a technology into organisational rhythms, policies, expectations, and discourses (Carroll & Conboy, 2020; Sooklal et al., 2011). It marks the point where a tool transitions from novel or disruptive to a component of everyday work infrastructure – so integrated that its presence may no longer be consciously acknowledged by users (Bax, 2011). This involves a deep alignment between the technology's functions and organisational norms, whereby managerial discourse and power structures frame its use as 'common sense' (Flichy, 1998).

Within the STS tradition, normalisation is understood as a cumulative process occurring through social practice. Technologies do not arrive pre-formed or stable; rather, they are co-constructed through ongoing negotiations across time, space, and actor networks (Hyysalo et al., 2019), challenging linear adoption models and calling for longitudinal analyses that consider the diversity of implementation contexts.

NPT, developed by May et al. (2009), outlines four key mechanisms of embedding: coherence (sense-making), cognitive participation (engagement), collective action (operationalisation), and reflexive monitoring (evaluation). These mechanisms explain how individuals and groups come to understand, commit to, and sustain technological practices. Yet normalisation is rarely straightforward, as it involves ongoing work in which actors negotiate meaning, reconfigure responsibilities, and redefine routines to embed a technology in everyday work (Melby & Hellesø, 2014).

Critically, normalisation is not merely an outcome but a strategic and discursive process, shaped by managerial narratives that define "successful" implementation. Over time, these discourses can obscure earlier frictions or resistances by institutionalising specific framings of the technology's value. Flichy (1998, p. 109) conceptualises normalisation as creating a "boundary-object", a sociotechnical construct that enables coherence across different communities of practice, facilitating a technology's stabilisation and making it amenable to scaling.

Situated practices: Contingent use of technology

Situated practices refer to the locally enacted, often informal, and improvised activities through which individuals engage with technology in specific settings (Neufeld & Delcore, 2018). These practices reveal the dynamic interplay between institutional structures and user agency, exposing how technologies are reconfigured and reinterpreted "from below" through context-dependent interactions shaped by local knowledge and informal adaptations (Turner, 2011; Sun, 2012).

Socio-material perspectives reveal how technologies are continually reconfigured through embodied interaction. As Suchman (1987) argues, action is shaped by emergent conditions rather than following predefined plans. Users actively interpret and negotiate technologies through situated practice (Orlikowski, 2000; Nicolini, 2012), modifying tools, working around constraints, or appropriating functionalities for unintended purposes. These micro-level adjustments are central to a technology's success or failure, recasting employees as active co-constructors. For example, Skjølsvold et al. (2015) show that systems like smart grids function as 'situated technologies', shaped by local socio-material contexts. Meanwhile Sackey et al. (2015) demonstrate how Building Information Modelling (BIM) implementation is closely tied to organisational culture and existing practices, highlighting the analytic value of situated practices in explaining the variability of technology integration.

Human-centric approaches further emphasise the emotional and cultural dimensions of engagement. As Cavelty (2018) argues, technological systems are inseparable from users' beliefs and values. Müller and Kenney (2014, p. 537) capture "situated moments of reflection, connection, and disruption", showing how individuals may contest or reframe dominant technological narratives. From a practice-based perspective, technologies are co-constituted with the environmental rhythms, bodies, and discourses within which they operate

(Suchman, 2006). Recognising technology's social and political situatedness enables more democratic and inclusive approaches to design and governance (Ribeiro et al., 2018; Latimer & Gómez, 2019).

The Normalisation-Situated Practice Matrix

By combining the concepts of normalisation and situated practice, we can bridge macro-level institutional logic with micro-level user experience, aligning with socio-material theories that emphasise the mutual constitution of actors and artefacts (Orlikowski, 2007; Leonardi, 2011; Scott & Orlikowski, 2025). This reorients attention from technologies as 'finished' innovations toward processes integrating initial scientific development phases with practical application (Lyle, 2021, p. 411).

The Normalisation-Situated Practice Matrix's contribution is best understood in terms of the analytical visibility it provides that adjacent frameworks cannot. NPT operates along a single evaluative dimension, the degree of normalisation, treating successful institutional embedding as its primary analytical endpoint. In doing so, it lacks the conceptual grounding to account for configurations in which high normalisation coexists with low experiential engagement, the condition we term Formal Compliance. Within an NPT framework, such configurations produce no analytical signal: the coexistence of deep institutional embedding and limited user engagement cannot be registered as a theoretically significant or potentially enduring outcome. Our matrix addresses this limitation directly by introducing situated practice engagement as a second, independent dimension, making this disjunction a legible and actionable analytical category. Practice-based and socio-material frameworks foreground the contingent, locally enacted dimensions of technology use, but typically lack systematic mechanisms for locating situated practices relative to organisational structures. The matrix provides this relational mapping. It differentiates whether situated engagement occurs with institutional support (Embedded Routine) or without it (Local Experimentation), a distinction carrying substantially different implications for sustainability and scalability. While prior scholarship has applied NPT to enterprise technology contexts to examine how technology-driven work practices become embedded and routinised (Carroll & Conboy, 2020), such work has generally remained within NPT's own analytical boundaries rather than treating (non-)alignment between institutional embedding and user engagement as a distinct analytical concern. This is the matrix's core contribution: not the prediction of adoption trajectories but the systematic surfacing of the configurations and tensions that shape them, making visible the use states that matter most for material interventions and for understanding the fundamentally human and relational dimensions of technological change.

The x-axis represents the Level of Normalisation: the extent to which a technology is formally embedded into organisational routines, structures, and policies (Carroll & Conboy, 2020) (Figure 1). The y-axis represents the Level of Situated Practice engagement: the extent to which employees use the technology in embodied, adaptive, and meaningful ways (Berner, 2008) (Figure 1). Each axis is a continuum from low to high, enabling categorisation into four

quadrants that allow for informed interpretation of how formal systems and lived practices align or diverge. This reframes success as a relational and negotiated outcome.

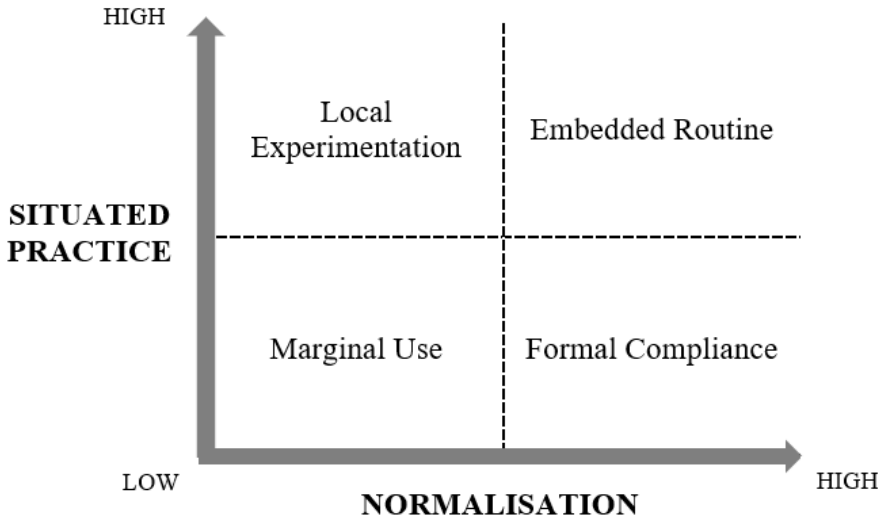

Figure 1. Normalisation-Situated Practice Matrix

The four quadrants of technology integration

The four quadrants represent distinct configurations of technological integration, offering analytical lenses for how formal organisational embedding and experiential user engagement intersect.

Low Normalisation–Low Situated Practice: Marginal Use

This quadrant characterises contexts where technology fails to integrate meaningfully into work practices due to both limited institutional embedding and user disengagement. Technologies in this quadrant remain peripheral, viewed as irrelevant rather than essential to task performance (Bax, 2011). The absence of cognitive participation and formal institutional support results in widespread disengagement (Hall et al., 2017), while inadequate operational design fails to incorporate novel tools effectively. When technologies are imposed without considering contexts, users struggle to develop structured or embodied practices, obscuring the interdependencies between social and technical factors (Crabtree et al., 2024; Macpherson & Clark, 2009). Without communities of practice to foster collective learning, shared understandings of effective technology use cannot develop (Wenger, 1998; Hsiao et al., 2003).

High Normalisation–Low Situated Practice: Formal Compliance

In this quadrant, technology implementation is driven by top-down mandates with minimal local adaptation and limited workforce engagement (Powell & Colin, 2009). Technology use is normalised at the policy level but remains superficial, employed to fulfil compliance requirements rather than enhance operational effectiveness. Adherence to usage protocols irrespective of workflow alignment fosters a dynamic of procedural compliance, where strict

managerial enforcement often overlooks productivity trade-offs and where employees find it challenging to use mandated tools effectively without feeling a sense of ownership or meaningful interaction (Hall et al., 2017). Training focuses on operational functionality while neglecting reflective practice development, creating a disconnect between formal instruction and the actual experience (Halperin, 2017). When tools are decoupled from the social contexts of work, they become rigid artefacts rather than enablers of meaningful practice (Kendall et al., 2020), resulting in limited knowledge transfer as users struggle to perceive the tools' relevance (Pine & Mazmanian, 2017).

Low Normalisation–High Situated Practice: Local Experimentation

This quadrant reflects adaptive employee behaviours operating with minimal institutional support. At initial technology deployment stages, situated interventions reveal how technologies and practices are co-shaped in context, turning uncertainty and friction into learning and innovation (Zuiderent-Jerak, 2015). Employees demonstrate high agency, using experiential knowledge and peer collaboration to develop effective, context-sensitive solutions outside formalised procedures. This capability is supported by creative self-efficacy, a psychological readiness that enables employees to innovate in the absence of institutional scaffolding (Puente-Díaz, 2016). Informal networks facilitate the exchange of insights and the collective construction of localised strategies, fostering collaboration and co-constructing tacit knowledge bases that may remain invisible to institutional mechanisms (Hara, 2009; Frisk & Middelkoop, 2023). This dynamic space of engagement, where creativity, improvisation, and collective intelligence thrive despite low institutional normalisation, reveals how employees creatively respond to systemic gaps and repurpose technologies to address immediate functional demands (Latimer & Gómez, 2019).

High Normalisation–High Situated Practice: Embedded Routine

This quadrant represents the configuration where technologies are meaningfully embedded through mutual reinforcement between formal structures and informal, embodied practices. From a socio-material perspective, this quadrant reflects technology and work co-constitution, where technologies are enacted through and within social practices rather than serving as merely instrumental tools (Cecez-Kecmanovic et al., 2014). Formal structures meet technological normalisation preconditions, while frontline routines adapt these structures to the dynamic realities of everyday work (Crompton, 2019; Pine & Mazmanian, 2017). Dynamic adaptation capacity proves vital during disruption, as effective organisational responses depend on seamless transitions between formalised protocols and improvisational problem-solving (Poutanen et al., 2016). Reflexive monitoring enables continuous evaluation (May et al., 2009). Distributed agency ensures technology evolution is informed by both formal decision-makers and frontline workers (Leonardi, 2011), and institutional memory captures lessons learned (Labatut et al., 2012). These mechanisms create self-reinforcing cycles in which organisational practices develop momentum that recursively reproduces and strengthens particular patterns of action (Kremser & Sydow, 2022).

Technology background: Occupational exoskeletons

Occupational exoskeletons are wearable assistive devices designed to support employees in physically demanding environments, addressing significant concerns around musculoskeletal disorders, fatigue, and productivity (Theurel & Desbrosses, 2019). Research indicates that their adoption can decrease physical workload and alleviate strain (Crea et al., 2021; Kermavnar et al., 2021), yet user experiences vary significantly. Some employees report enhanced comfort and reduced fatigue, while others experience discomfort, emphasising the importance of individual differences in design and implementation (Botti & Melloni, 2023).

Successful exoskeleton implementation requires empirical, in situ validation that assesses effectiveness within specific workplace environments (Crea et al., 2021; Botti & Melloni, 2023). Social factors also matter: Elprama et al. (2020) demonstrated that perceived ease of use and social influence are key predictors of industrial workers' intention to use exoskeletons, while Shore et al. (2018) argue that directly involving users as co-designers is crucial to maximising acceptance and reducing stigma associated with assistive devices. The interaction between exoskeletons and individuals' self-efficacy plays a pivotal role; tangible reductions in physical strain often encourage further engagement (Siedl & Mara, 2021; Siedl et al., 2024). Andrade and Nathan-Roberts (2022) emphasised that one-size-fits-all approaches are ineffective and that exoskeletons must be tailored to specific job requirements and user needs, a conclusion echoed by Crea et al. (2021) calling for systematic field validation across different real-world settings.

Methods

This study was conducted as part of a wider interdisciplinary project developing human-centric approaches to technology integration for workforce empowerment.

Research design and context

This qualitative case study employs thematic analysis to examine how different stakeholders interpret and challenge the practical application of exoskeletons. The study investigates the implementation of the Auxivo LiftSuit 2.0 occupational exoskeleton within a warehouse organised around Picked-by-Line (PBL) and Temperature Controlled (TC) operational models, examining how its adoption is shaped by stakeholder-ascribed meanings and daily work practices. The focus on this industrial logistics context stems from the broader tension between technological innovation and real-world implementation; in the logistics sector, exoskeletons are often introduced in response to high rates of musculoskeletal stress, workforce shortages, and productivity demands (Crea et al., 2021; Schrøder Jakobsen, 2024).

Participants and data collection

Empirical data was gathered through semi-structured interviews and direct participant observation. A total of 34 interviews were conducted with a diverse range of participants, including frontline warehouse employees, managerial staff, technical developers, and academic experts (Table 1). Participants were recruited through a purposive sampling strategy, using criterion-based selection to recruit participants with relevant experience of exoskeleton use. Employees with operational exoskeleton experience were selected via managerial gatekeepers, while managers and experts were recruited based on their direct involvement and domain expertise. This recruitment strategy ensured representation across three key stakeholder groups: (1) direct users (warehouse operators, n=12), selected to capture variation in experience levels and exoskeleton usage patterns; (2) organisational decision-makers (operational managers, n=7) representing different functional areas; and (3) technical and academic experts (n=15) including ergonomists, researchers, professors, and developers with specialised knowledge of exoskeleton technology and human-centred design. This distribution was designed to triangulate perspectives and capture a wide spectrum of implementation experiences, from frontline embodied practice to strategic decision-making and technical expertise. Ethics approval for the study was obtained from the relevant ethics review board prior to the start of the research, and informed consent was granted by participants.

Exoskeleton case study participants	
Operators	12
Operational managers	7
Ergonomists	2
Researchers (HC technologies, UX design, robopsychology)	5
Professors (ergonomics, human factors, operations and innovation management, biorobotics)	4
Technical developers and project leads	4
Total	**34**

Table 1. Interviews with participants across the exoskeleton case study

Observational data was collected during a week-long site visit to a large European warehouse facility. The observations focused on exoskeleton usage patterns, workplace interactions and the physical environment. Field notes documented body movements, device adjustments, peer interactions, informal problem-solving and discrepancies between prescribed and actual usage. A participant-observer approach was adopted, involving informal conversations with operators during breaks. These observations complemented interview data, revealing tacit practices and non-verbal aspects of technology adoption that participants might not have articulated in interviews.

Data analysis

The analysis examined technological adoption at the intersection of organisational structures and everyday practices using Atlas.ti software. The analytical process was conducted through four iterative phases. In the first phase, all interviews were transcribed, pseudonymised, and subjected to initial inductive coding. This helped ensure interpretive consistency and enabled ongoing dialogue about emergent themes. Through this inductive process, initial empirical patterns suggested a two-dimensional space defined by the degree of organisational embedding and the degree of experiential user engagement; the core structure of the matrix thus emerged inductively from the data before being theoretically refined. In the second phase, codes were organised into thematic clusters through constant comparison, enabling identification of patterns of convergence and divergence across stakeholder groups. Codes were iteratively refined through successive passes over the data with authors comparing, splitting, and merging codes to improve analytical precision and ensure internal coherence within each thematic cluster. In the third phase, a theoretically informed stage drew on normalisation and situated practice literature to develop higher-order categories. Thematic codes were re-examined in the context of the matrix's core quadrants, with codes mapped to axes and quadrant-specific patterns identified. This phase also involved mapping the inductively derived two-dimensional structure onto the theoretical concepts of normalisation and situated practice, resulting in the final model. In the fourth phase, analytical validity was confirmed through triangulation across multiple data sources and stakeholder perspectives, ensuring that thematic patterns reflected convergent evidence. While the sample captured substantial thematic recurrence across stakeholder groups, we do not make formal claims of theoretical saturation. Instead, we observed that the final stages of coding produced fewer new themes, and that triangulating the analysis with interviews, observations, and expert perspectives increased its robustness.

Exoskeleton implementation through the Normalisation-Situated Practice Matrix

Four unique patterns of technology integration were identified through thematic analysis of observational and interview data, corresponding to the quadrants of the Normalisation-Situated Practice Matrix. These patterns are not mutually exclusive categories; rather, they represent the dominant and sometimes overlapping dynamics that emerged as stakeholders negotiated the use of exoskeletons in their daily work.

Marginal Use: Limitations override formal support and user engagement

Despite widespread implementation processes across industries, exoskeletons frequently remain at the margins of workplace practice due to fundamental technical limitations that manifest as both physical and psychological disengagement. This exemplifies how employees can experience technology as burdensome rather than beneficial when there is inadequate alignment between technology design and deployment environment demands (Wong et al., 2023).

Movement restriction represents the most significant technological limitation, with experts noting "inflexible rigid elements" that disrupt natural movements (Sophie, expert). Order-picker employees face particular challenges, as they must walk with the device approximately 80% of their shift (Percy, expert), and the devices also "limit lateral movement" and interfere with other equipment (Noah, operator). These restrictions disrupt established movement patterns (James, operator), with one employee comparing the experience to confinement (Leo, operator). These observations demonstrate how users can perceive technology as counterproductive (Pine & Mazmanian, 2017).

Beyond physical constraints, invisible frictions significantly undermine integration. Employees understood the exoskeleton's preventive purpose but expressed scepticism. Some operators felt exoskeletons were introduced too late to address existing injuries (Lucas, operator), and others lacked motivation due to dissatisfaction with the device (Benjamin, operator). Such doubts contribute to ongoing debates about whether operators should wear devices without clear evidence of benefits (Kenneth, expert), especially as infrastructure limitations compound concerns (Lilian, expert). User agency compounds these issues, with experts noting that unwilling users will avoid device use (Percy, expert), sometimes with complaints of persistent pain (Emily, operator; Benjamin, operator; Leo, operator). Tacit resistance typically results in quiet abandonment, as users revert to established practices when confronted with inadequately integrated systems (Lyle, 2021). Physical discomfort from heat and weight creates additional barriers. Warehouse temperatures frequently exceed 25°C, causing "terminal discomfort" from excessive sweating (Julian, expert), with many employees identifying thermal issues as their primary concern (Ethan, operator; Liam, operator; Jack, operator).

Formal Compliance: Top-down implementation without user engagement

In top-down implementation, organisational processes dominate over user experience. This is characteristic of environments where new ideas and technologies signal a commitment to innovation rather than meaningful improvements to everyday work practices (Bednar & Welch, 2020). Strategic choices are made by management with minimal employee input (Lilian, expert; Kimberly, expert), and technology is followed as a directive rather than meaningfully integrated. This dynamic reflects broader patterns of organisational power asymmetry (Clegg et al., 2006), where authority to mandate adoption concentrates at executive levels while frontline workers bear the embodied consequences. However, our findings reveal that power relations are not unidirectional; employees exercise agency through tacit resistance and informal adaptation strategies.

Expert consensus strongly favours voluntary approaches, highlighting that the "main difficulty is when management says it's obligatory" (Kenneth, expert) because mandatory use leads to immediate dislike (Philip, expert). This aligns with employees' preferences for voluntary use and individual choice (Noah, operator; Ethan, operator; Leo, operator). Managerial views remain divided: while some advocate for mandatory use to ensure consistent adoption and

reduce strain-related injuries (Daniel, manager), others question the health implications of requiring use without consent (Emma, manager).

Risks of improper implementation are evident when workers wear devices incorrectly and experience disappointment (Sophie, expert), reinforcing the necessity of ongoing technical assistance. Employees highlighted positive training experiences (Olivia, operator), emphasising field-based instruction that reflects task realities, including necessary device adjustments (Henry, operator). Comprehensive support systems require a central contact point for monitoring concerns (Violet, expert; Kimberly, expert; Julian, expert) and ensuring device proximity (Caroline, expert).

Reduced productivity concerns represent a major barrier for operators (Lilian, expert; Julian, expert): "My difficulty was that I like to produce quickly, and I realised that with the exoskeleton I cannot do that much. […] I am worried about my production getting lower" (Olivia, operator). This tension creates ongoing stress, particularly among employees with performance-based pay structures, though some managers alleviate this concern by informing employees that pay would not be affected (Owen, manager).

Local Experimentation: Employee-driven adaptation and learning

Local experimentation emerges when employees actively engage with exoskeleton technology despite limited formal support. Adaptations emerge organically through necessity and contextual understanding rather than top-down directives (Murray et al., 2010; Wong et al., 2023).

Design flexibility proves crucial, with employees consistently advocating for customisation and choice, such as a "catalogue of exoskeleton models" allowing selection based on personal needs (Sophie, expert). This involves explicit advocacy for testing and choosing from different models (Noah, operator; Lucas, operator; Leo, operator; Benjamin, operator), reflecting needs for autonomy and control over workplace technology. Experts recognise time lags between initial device reception and full adaptation (Philip, expert), highlighting the value of experiential learning. The significance of user control over implementation timing and duration is also recognised, alongside advocacy for participatory strategies that give employees ownership (Marcus, expert).

Peer dynamics significantly influence adoption. Positive experiences within one department often spark curiosity and interest in others (Evelyn, operator). Employees frequently rely on informal networks to share insights and develop localised strategies, helping repurpose technologies to yield unforeseen benefits (Carroll et al., 2002; Kendall et al., 2020). Exoskeleton adoption often involves fundamental relearning: "I had to relearn how to work with an exoskeleton" (Olivia, operator) which can also highlight previously unnoticed problematic habits and postures (Emily, operator; Henry, operator). Informal peer knowledge sharing provides support during adaptation, with users warning about temporary leg pain while anticipating back improvement (Ethan, operator).

Embedded Routine: Collaborative integration and systematic feedback

Embedded Routine represents a progression from Local Experimentation to structural embeddedness. It represents the most effective pattern, characterised by comprehensive stakeholder participation and systematic feedback mechanisms ensuring sustainable technology integration. This culture encourages employee participation in decision-making and fosters collective ownership of technological systems (Wong et al., 2023). Employee autonomy is structurally supported, and managerial frameworks enable ongoing technological adaptation.

In practice, this requires organisational structures facilitating genuine participation through stakeholder discussion tables (Caroline, expert). Participation is sustained by trust, clarity, and transparent processes (Stella, expert), which help recognise employees as domain experts (Sophie, expert). Technology adoption is characterised by collaborative co-construction requiring extensive stakeholder involvement beyond direct users, including unions, supervisors, managers, physicians, ergonomists, and engineers. Knowledge is co-created rather than merely transferred. Implementation involves iterative collaboration through "cognitive walkthrough[s]" balancing employee expectations and employer intentions (Stella, expert). Communities of practice facilitate knowledge building by encouraging purposeful conversations that enhance the contextual understanding necessary for members to interpret and apply knowledge effectively (Hoadley & Kilner, 2005), within which knowledge is continuously refined and internalised through use.

Feedback is treated as an ongoing process embedded within daily operations. Effective feedback collection involves reflective practice that moves beyond surface impressions (Stella, expert) and must capture multiple dimensions through talking, observing, interviewing, and determining redesign needs (Kimberly, expert). When employees provide input into personalisation, it ensures "a better employee" (David, expert). Managers recognise feedback's role in helping employees feel "they are part of the business, part of the team" (Daniel, manager), a notion reflected by employees: "if we have something to point out, good or bad, we talk" (Henry, operator).

Successful integration often begins with positive initial technology uptake, where users embrace new tools when perceiving immediate, tangible benefits (Murray et al., 2010). Many employees expressed enthusiasm and motivation about participating in trials (Emily, operator; Ethan, operator; Olivia, operator). Employees with prior health concerns or greater occupational risk awareness demonstrate higher receptivity to exoskeleton adoption (Alexander, manager). This suggests that personal relevance and physical context remain key factors in long-term integration. The subsequent adaptation process involves gradual habituation where employees eventually cease noticing the exoskeleton during work activities (Henry, operator), representing successful integration through exoskeleton "transparency" (Philip, expert).

Sustained impact extends beyond device use, with employees reporting improved posture, "even without any preparation, it is more upright" (Noah, operator), and better self-perception: "you feel better about yourself, about your body and you feel more relief" (Olivia, operator). Management increasingly views exoskeletons as components of broader ergonomic interventions rather than standalone solutions (Michael, manager), reflecting understanding of comprehensive workplace health approaches.

Analytical implications: Navigating the matrix for human-centric adoption

The matrix makes the positionality of the technology adoption process diagnostically visible. By treating Embedded Routine as an optimal configuration, it clarifies what is lacking elsewhere, not as a normative judgement but as an analytical baseline against which other configurations can be interpreted. Our analysis reveals that this configuration depends on alignment between organisational discourse, material conditions, and user adaptations. Technologies may achieve formal embedding without meaningful user engagement (Formal Compliance) or generate strong user engagement without organisational support (Local Experimentation). Navigating between these configurations requires understanding both what sustains and what undermines each.

When adoption falls into *Marginal Use,* it signals fundamental misalignment between system design and deployment conditions. Our findings indicate that technical limitations – particularly movement restrictions, heat discomfort, and invisible frictions – overrode even well-resourced, formal implementation efforts. These problems are unlikely to be resolved through formal processes alone. This highlights the importance of participatory approaches that incorporate end users in the design and implementation stages, in order to tailor technologies to real needs and contexts (Steen, 2011), and the importance of integrating iterative feedback loops into project timelines (Carreno, 2024). Without intentional efforts to address these barriers, the technology is unlikely to advance beyond marginal status.

Formal Compliance indicates that technology is perceived as a managerial imposition. Our evidence shows that mandatory approaches generated resistance among participants, while productivity concerns created ongoing tension. These findings suggest that qualitative investigation of the gap between policy and practice, through walkthroughs and informal conversations, can reveal why deeper engagement is absent. Our analysis points to the value of creating space for situated practice, empowering teams to adapt usage protocols and addressing legitimate compensation concerns. Involving employees in these processes enhances commitment and diminishes perceptions of imposition (Alqahtani & Braun, 2021). By combining bottom-up engagement with top-down normalisation, organisations may create conditions conducive to Embedded Routine.

Local Experimentation, rather than threatening standardisation, represents latent organisational intelligence. Employees in our study developed adaptation strategies – from

strategic timing of device use to peer-to-peer knowledge sharing – that often exceeded formal implementation plans. Instead of suppressing "unauthorised" practices, the findings suggest that organisations could benefit from legitimising and learning from them. Establishing formal channels to capture employees' tacit knowledge could transform experience-based insights into organisational assets. Integrating these insights creates an environment that actively facilitates knowledge sharing among employees, thereby enhancing innovation capabilities (Oliveira et al., 2020), and establishing pathways towards Embedded Routine.

Sustaining *Embedded Routine* requires active maintenance rather than passive monitoring. Our findings suggest that protecting the autonomy of communities of practice, maintaining open feedback loops, and acknowledging collaborative success could prevent regression into Formal Compliance as organisational priorities shift. Sustainable technology integration depends on recognising employees as co-designers of technology application (Navarro-Meneses & Pablo-Marti, 2025). Formal systems are designed to support user-driven adaptation and learning processes; iterative feedback and collaborative problem-solving processes are key to maintaining engagement and supporting continuous improvement (Carreno, 2024; Shannon, 2021).

Discussion

Managerial implications: Four important considerations

The four quadrants represent configurations within an ongoing adoption process, not static classifications. Design choices determine whether movement between them is possible. By providing resources and structure, an organisation can potentially transform the bottom-up efforts of Local Experimentation into reliable practice, consistent with descriptions of situated co-production (Broadhurst & Mason, 2014; Crompton, 2019). Similarly, encouraging genuine user engagement can reconfigure the top-down requirements of Formal Compliance. If technological issues and user needs are ignored, any initiative risks collapsing into Marginal Use. Reaching Embedded Routine is only one aspect of reframing success; another is increasing an organisation's capacity to learn from each configuration and manage transitions between them. Our findings suggest that interference with natural movement rhythms represents a fundamental design concern: even minor restrictions provoked strong psychological resistance among participants, while heat and weight limitations eroded positive initial uptake over time. These findings align with recent exoskeleton studies that emphasise the role of perceived usefulness and long-term wearability in shaping user acceptance (De Looze et al., 2016; Andrade & Nathan-Roberts, 2022; Siedl & Mara, 2021; Wioland et al., 2025).

Second, our findings point to the importance of transparent communication in bridging credibility gaps. Invisible frictions, such as employees outwardly complying while covertly

abandoning devices, can mislead organisations with false success metrics. Being clear about both the benefits and limitations of new technology implementation appears essential to manage the social dynamics between "believers" and "sceptics", a point consistent with Dhondt et al.'s (2017) argument that open, reciprocal communication among stakeholders fosters positive industrial relations.

Third, our analysis indicates that implementation strategy shapes adoption trajectories. Mandatory implementation tended to trigger disengagement among our participants, whereas a guided voluntary approach relying on trusted peer ambassadors and social influence was associated with more successful adoption. This finding aligns with recent research confirming that peer endorsement within workplace networks accelerates innovation uptake and strengthens user commitment (Brykman & Raver, 2023).

Fourth, the findings highlight organisational readiness as a decisive factor. Successful technology adoption requires more than 'good' technology; it requires a supportive ecosystem including dedicated champions, adequate infrastructure, clearly defined issue-resolution protocols, and cultural alignment (Leonardi & Barley, 2008; Howell & Higgins, 1990; Schein, 2010). Without these enabling conditions, advanced technologies encounter difficulties in becoming integrated into everyday practices.

The matrix as a diagnostic tool

The matrix's value lies not in specifying what organisations should do but in making visible where they are. By identifying which configuration best describes a current technology initiative, organisations can assess their position and develop targeted strategies for progression.

Moving from Local Experimentation to Embedded Routine involves providing structural support, formalising successful informal practices and scaling up peer-led initiatives while preserving the enthusiasm that drives them. Our evidence indicates that individual variation in body types, job responsibilities, and personal preferences renders one-size-fits all approaches ineffective. Organisations should consider offering device selection, including aesthetic and design choices, to ensure alignment with employees' identities and comfort. Our analysis also suggests that exoskeletons may function as situational or educational tools to improve posture awareness. Daily appropriation patterns, where employees prefer task-specific use rather than continuous wear, point to the need for gradual familiarisation processes that accommodate individual rhythms of adoption. This finding highlights the importance of extended real-world trials over short laboratory demonstrations.

Moving from Formal Compliance to Embedded Routine requires transforming top-down mandates into collaborative adaptation processes through genuine user engagement and feedback mechanisms. Initial engagement strategies could target groups most likely to benefit, such as new employees or those with health concerns, to build momentum.

Sustained adoption appeared to depend on whether the technology became "transparent"' to users, integrating into workflow without persistent intrusions. Combining top-down structures with peer-led dynamics, where early adopters and respected employees can inspire enthusiasm and spark interest, may facilitate this transition.

Avoiding Marginal Use demands devoted attention to user needs, technological limitations, and continuous organisational learning. Low levels of both formal support and employee engagement signal that fundamental reassessment is needed to prevent initiatives from deteriorating into superficial adoption or abandonment.

Limitations and future directions

Several limitations require careful consideration. Firstly, this study is based on a single-case design, focusing on the physical and embodied aspects of exoskeletons. This approach may have amplified certain dynamics that are less pronounced for other technology types. The physical and embodied aspects of exoskeletons may intensify user experiences in ways our matrix captures well but which may be less salient for cognitive or purely digital technologies. Technologies such as AI decision-support systems may exhibit different dynamics along the situated practice axis, as their adoption depends more on cognitive integration and information flows. The matrix's utility for other technology classes remains an empirical question requiring validation through comparative studies across technology types (embodied vs. cognitive, physical vs. digital), which would help establish the matrix's scope conditions and identify necessary modifications for broader applicability.

Second, our observational data was collected during a week-long site visit. While this was complemented with 34 semi-structured interviews, the cross-sectional nature of the fieldwork represents a limitation, given that we frame technology adoption as an iterative, longitudinal process. The matrix's quadrants describe dynamic configurations that shift over time; capturing these shifts in real time would require sustained ethnographic engagement. Future studies could employ longitudinal methodologies, where employees use technologies over months or years, tracking how initial barriers or benefits shift and how configurations migrate across quadrants.

Third, we recognise that technology adoption reflects and reproduces existing power relations (Clegg et al., 2006). The Formal Compliance quadrant reveals the exercise of managerial prerogatives, while Local Experimentation represents employees' tactical responses to limited formal authority over technology choices. Future research could explicitly examine how participatory approaches can challenge existing power structures and whether the matrix can be used not only to diagnose configurations but also to facilitate more equitable participatory processes.

Conclusion

This study demonstrates that combining normalisation and situated practice perspectives provides a practical lens for understanding and improving technology integration in complex organisational settings. It argues for a reframing of success: moving away from a binary focus on acceptance or resistance toward a more nuanced appreciation of sociotechnical alignment. The Normalisation-Situated Practice Matrix provides the conceptual structure for this reframing, mapping visible the configurations through which technology adoption unfolds without reducing them to predetermined outcomes. As Pasmore et al. (2019) contend, ensuring human needs and social systems are respected and harmonised with the benefits of technology has never been a more critical concern. True success for technology integration, as becomes apparent in the case of exoskeletons, is an emergent property of the ongoing negotiation between users, designers, institutions, and cultural discourses, shaped by an organisation's ability to navigate the dynamic configurations of this process.

Technology adoption should be seen as a situated, iterative process. This aligns with both Suchman (2006) and Gherardi (2008), who indicate how technology use is shaped by local contexts, employee experiences and organisational realities, requiring continuous feedback, adaptation and co-creation. Our findings challenge the assumption that adoption failures stem primarily from user resistance or insufficient training, rather, successful adoption depends on organisational culture, social dynamics at the workplace and the alignment between institutional structures and embodied practice. Shifting to advanced technologies requires significant organisational investment, making correct adoption strategies crucial. Conventional, linear implementation approaches are insufficient. Success lies not in forcing compliance but in creating conditions where technology and human practice can adapt and evolve together, prioritising collaborative adaptation, informal peer learning and iterative feedback loops (Enkel et al., 2018). Exoskeletons and similar emerging technologies should be introduced as platforms for collaborative experimentation, enabling the co-evolution of technology, work practices and organisational processes. This signals a necessary shift toward more collaborative, sustained and human-centric adoption processes in organisations.

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