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# Enabling Lean Construction 4.0 through human-centric digital transformation: organisational leadership insights

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## Abstract

**Purpose** – This study investigates the challenges construction organisation leaders face when implementing human-centric digital transformation to enable Lean Construction 4.0. It aims to provide insights into how organisations can effectively manage the human aspects of digital transformation while addressing industry-specific barriers to lean implementation.

**Design/methodology/approach** – The research employed a qualitative approach through semi-structured interviews with senior organisation leaders from construction organisations across New Zealand, Australia, the UK and Denmark. Data analysis followed a systematic thematic analysis approach to identify key challenges and patterns.

**Findings** – The study revealed ten key challenge areas in implementing human-centric digital transformation for Lean Construction 4.0: strategic vision communication, organisational competencies assessment, training development, resource allocation, employee involvement, value integration, technological adoption, performance monitoring, well-being support and cultural reinforcement. Critical barriers include the industry's traditionally low-profit margins limiting investment capacity, high staff turnover rates complicating training initiatives and resistance from long-tenured employees transitioning from memorised to documented processes. The findings highlight how the construction industry's unique characteristics create distinct challenges in terms of implementing Lean Construction 4.0 that extend beyond general digital transformation barriers.

**Originality/value** – This study is among the first to specifically examine human-centric digital transformation challenges in implementing Lean Construction 4.0 in construction organisations from a leadership perspective. It contributes to both theory and practice by providing a comprehensive understanding of the barriers that leaders face when implementing digital transformation while maintaining a human-centric focus. The findings bridge the gap between theoretical understanding and practical implementation of Lean Construction 4.0, offering insights for construction organisations seeking to balance technological advancement with human factors.

**Keywords** Lean Construction 4.0, Change management, Digital transformation, Human-centric approach, Organisational development, Leadership challenges

**Paper type** Research article

## 1. Introduction

Despite its economic significance, the construction industry faces ongoing challenges in adopting digital technologies and Industry 4.0 innovations (Maskuriy *et al.*, 2019). Lean

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Construction has emerged as a critical methodology to address these challenges, focusing on minimising waste, improving efficiency, and optimizing value creation (Sirwardhana and Moehler, 2023). The evolution toward Lean Construction 4.0 represents the integration of lean principles with digital technologies to further enhance construction processes and outcomes (González *et al.*, 2022). The industry's transition into digital transformation brings particular challenges in balancing technological advancement with human-centric principles, requiring organisations to maintain focus on creativity, critical thinking, and personalisation while pursuing technological progress (Townsend, 2024).

Digital transformation efforts in the industry often encounter significant barriers, with McKinsey reporting a mere 16% success rate and an additional 7% achieving only temporary improvements. These shortcomings are frequently attributed to a lack of employee readiness, insufficient skills, or flawed processes, which prevent organisations from fully realising the benefits of digital tools and lean methodologies. Effective digital transformation requires a harmonious blend of human capabilities and digital technologies, emphasising a human-led, technology-enabled, and customer-centric approach that aligns with the core lean principle of respect for people. This process necessitates continuous learning, adaptation, and an innovative mindset to navigate the complexities of constant change (McKinsey and Company, 2023).

Change management theory has emerged as the most appropriate theoretical framework for addressing these challenges in the construction industry context. Unlike other organisational theories that focus on specific aspects of transformation, change management theory provides a comprehensive approach that addresses the complex, multi-faceted nature of digital transformation in construction organisations (Bröchner and Badenfelt, 2011). The construction industry's unique characteristics, including project-based operations, temporary multi-organisational alliances, fragmented supply chains, and traditional work practices, require frameworks that can manage transformation across diverse stakeholder groups, varying organisational structures, and different levels of digital maturity (Oesterreich and Teuteberg, 2016). Change management theory encompasses these broader organisational dimensions, offering structured approaches for managing cultural transformation, stakeholder engagement, leadership alignment, and sustainable behavioural change necessary for successful Lean Construction 4.0 implementation (Hayes, 2006; Kotter, 2009; Pacolli, 2022). Research underscores the importance of structured change management approaches in managing the people side of change, which is essential in an industry facing both evolving market demands and technological disruption (Bellantuono *et al.*, 2021; Robertson and De Vellis, 2023). However, the construction industry's unique complexities demand a tailored application of these principles to address sector-specific challenges effectively and implement Lean Construction 4.0 successfully (Ghaffar *et al.*, 2022).

While digital transformation and Lean Construction 4.0 are conceptually distinct, this study examines their intersection through the lens of human-centric implementation challenges. Lean Construction 4.0 represents the specific application of digital transformation principles within lean construction contexts, requiring change management approaches that address both technological adoption and lean principle integration simultaneously (Bidhendi *et al.*, 2025). The identified change management challenges apply specifically to this lean-digital integration context rather than general digital transformation initiatives.

This study addresses a critical gap in understanding how construction organisations can effectively implement human-centric digital transformation to enable Lean Construction 4.0 while managing challenges unique to the industry. By examining the intersection of digital transformation, human-centric approaches, and change management in construction, this research provides vital insights for the industry that has historically struggled with technological adoption, lean implementation, and change initiatives. The findings are particularly significant given the construction sector's global economic importance and its current pressures to modernise while maintaining workforce engagement and productivity. The findings contribute to both theory and practice by offering a comprehensive framework

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for understanding and addressing the human aspects of digital transformation in construction organisations pursuing Lean Construction 4.0. This study aims to investigate the challenges construction organisation leaders face when implementing human-centric digital transformation to enable Lean Construction 4.0.: The specific objectives are to:

- (1) Identify and analyse the key challenges construction organisation leaders face when implementing digital transformation to enable Lean Construction 4.0
- (2) Examine how industry-specific characteristics create unique barriers to Lean Construction 4.0 implementation
- (3) Develop insights into effective strategies for managing these challenges while maintaining a human-centric focus
- (4) Provide foundational insights that inform future research on developing targeted change management strategies for addressing identified challenges.

This paper is structured as follows: [Section 2](#) reviews relevant literature on digital transformation, human-centric approaches, and change management in construction; [Section 3](#) details the research methodology; [Section 4](#) presents the findings; [Section 5](#) discusses the implications; and [Section 6](#) concludes with recommendations for future research and practice.

## 2. Research background

### 2.1 Digital transformation and lean construction 4.0

The construction industry is a vital contributor to the global economy, providing essential infrastructure and buildings that underpin multiple sectors. Despite its importance, the industry has historically been slow to adopt new technologies, relying heavily on manual labour and traditional practices ([Maskuriy et al., 2019](#)). However, recent years have witnessed a shift with the gradual adoption of Industry 4.0 technologies. This integration of Industry 4.0 in construction has given rise to the concept of ‘Construction 4.0’ - a paradigm that adapts Industry 4.0 principles specifically to the construction sector’s unique characteristics and challenges ([Alaloul et al., 2020](#)). Construction 4.0 encompasses the digitalisation of construction processes through technologies. These advancements include artificial intelligence, robotics, the Internet of Things (IoT), data analytics, and automation. Although the integration of Industry 4.0 in construction is still in its early stages, there is increasing interest and acknowledgement of its potential benefits ([Timchuk et al., 2021](#)). Studies indicate that the industry’s growing demand for faster and more cost-effective production has fuelled interest in these technologies ([You and Feng, 2020](#)).

Lean Construction 4.0 represents the strategic integration of specific lean principles with targeted digital technologies to create synergistic improvements in construction processes. The synergy manifests in three key areas: (1) Waste reduction enhancement, where digital technologies amplify lean waste elimination principles, for example, Building Information Modelling (BIM) eliminates design waste through clash detection, Internet of Things (IoT) sensors reduce material waste through real-time inventory tracking, and artificial intelligence optimises scheduling to minimise waiting time waste ([Ahmed and Kassem, 2018](#); [Sacks et al., 2020](#)); (2) Value stream optimisation, where digital tools enable real-time value stream mapping and monitoring, robotics and automation eliminate non-value-adding activities, data analytics identify bottlenecks in lean workflows, and digital twins provide continuous process improvement feedback ([Karmaoui et al., 2023](#)); and (3) Collaborative planning enhancement, where digital platforms support lean collaborative planning processes, cloud-based Last Planner Systems enable distributed team coordination, augmented reality facilitates lean visual management, and predictive analytics support lean pull planning principles ([Dave et al., 2016](#)).

The implementation of Lean Construction 4.0 requires a balanced approach that addresses both technological factors (digital infrastructure, data analytics capabilities, process automation technologies) and human factors (workforce capabilities, organisational culture, leadership competencies, and employee well-being) through strategic integration rather than parallel development (Oesterreich and Teuteberg, 2016; Bidhendi *et al.*, 2025). This balance is achieved through participatory design processes, synchronised capability development, and adaptive implementation strategies that ensure technological solutions enhance rather than replace human capabilities (González *et al.*, 2022). Bidhendi and Poshdar (2024) emphasise that successful implementation depends not only on technological solutions but also on the organisation's ability to manage change, develop appropriate skills, and foster a supportive culture. Central to this approach is the lean principle of "respect for people," which resonates with human-centric digital transformation by emphasising worker engagement and empowerment (González *et al.*, 2022). This principle becomes even more critical as digital technologies transform construction processes, requiring organisations to consider how technology can enhance human capabilities rather than simply replace them. As Gedara and Madusanka (2024) note, the true potential of Lean Construction 4.0 is realised when digital technologies are implemented in ways that support lean principles while acknowledging the essential role of human judgement, creativity, and expertise in construction processes.

While broader digital transformation literature provides general insights, the specific context of Lean Construction 4.0 presents unique challenges that warrant focused examination. Recent studies have begun to explore the intersection of lean principles with Industry 4.0 technologies in construction settings. Fang and Gao (2024) investigated Construction 4.0 technology and lean construction ambidexterity capability from a sociotechnical systems perspective, revealing that successful implementation requires balancing technological advancement with lean thinking capabilities. Their findings suggest that organisations must develop ambidextrous capabilities to simultaneously exploit existing lean practices while exploring new digital technologies.

Karmaoui *et al.* (2023) analysed lean and Industry 4.0 integration in construction manufacturing, highlighting the importance of value stream mapping and digital twin technologies. However, these studies primarily focus on technological integration aspects rather than the human-centric dimensions of change management.

## 2.2 Human-centric approaches in construction

The foundation of any organisation is its workforce, and neglecting employee well-being can lead to significant challenges for an organisation (Nakanishi, 2023). The concept of a human-centred organisation has garnered attention as companies increasingly recognise the value of prioritising people in their operations and decision-making. This approach highlights the importance of addressing the needs, welfare, and growth of employees, viewing them as a critical asset whose engagement and satisfaction drive organisational success. By fostering a human-centric culture, companies can gain a competitive edge in their respective industries (Hamid, 2019). Magalhaes (2021) underscores the importance of designing sustainable, human-centred organisations by combining global perspectives with localised actions. This strategy takes into account the diverse cultural contexts in which organisations operate, ensuring that human-centric practices are tailored to the specific needs of individuals across different regions.

In the specific context of Lean Construction 4.0, human-centricity encompasses four critical dimensions that directly impact digital transformation success. First, worker well-being and safety involve ensuring that digital technologies enhance rather than compromise physical and psychological safety (Nnaji and Karakhan, 2020). Second, job satisfaction and skill development focus on designing digital implementations that provide meaningful work and growth opportunities, such as using automation for repetitive tasks while enabling workers to focus on creative problem-solving, or implementing digital training systems that support

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continuous skill development (Li *et al.*, 2018). Third, collaborative decision-making ensures that digital tools support rather than undermine lean principles of worker empowerment (Oraee *et al.*, 2017). Fourth, cultural integration addresses how digital transformation aligns with lean construction's respect for people principle, ensuring that technology implementation processes involve worker participation, acknowledge traditional construction knowledge, and maintain human relationships essential to project success (González *et al.*, 2022).

In the construction sector, human-centricity is increasingly seen as essential in adapting to the digital era. Construction projects involve a wide range of stakeholders, including architects, engineers, contractors, suppliers, and clients (Bidhendi and Poshdar, 2024). A human-centric approach enables organisations to manage this diversity effectively, ensuring that all stakeholders' unique perspectives, preferences, and challenges are considered. By aligning processes and designs with stakeholder needs, construction companies can enhance collaboration, improve efficiency, and achieve better project outcomes. Moreover, adopting human-centric principles in construction promotes worker well-being, safety, and job satisfaction. Given the physically demanding and often hazardous nature of construction work, prioritising health and safety measures is crucial. Human-centric organisations also emphasise creating a supportive work environment that fosters employee development and growth (Paolillo *et al.*, 2016; Noueihed and Hamzeh, 2022).

Looking ahead, integrating human-centric approaches will be vital for shaping a construction industry that prioritises workforce well-being, promotes positive work environments, and ensures sustainable success in a rapidly evolving digital age (Talim, 2024).

### 2.3 Change management

Change management theory, fundamentally shaped by John Kotter's seminal work 'Leading Change', examines the strategies and processes involved in transitioning an organisation from its current state to a desired future state (Kotter, 1995). Change management includes understanding the factors driving change, assessing its impact on individuals and teams, and developing approaches to implement change effectively (Iskandar *et al.*, 2020). However, successful change implementation begins with identifying and understanding the specific challenges that leaders face during transformation initiatives, as these challenges form the foundation for developing targeted change strategies (Abbas and Asghar, 2010; Ramcharan and Parumasur, 2014; Errida and Lotfi, 2021). Over time, various change management models have been developed to provide organisations with structured frameworks for planning, communicating, and executing change initiatives. These models offer valuable guidance for navigating the complexities of organisational change (Bugubayeva *et al.*, 2017).

Organisational transformation, a multifaceted process involving changes to structure, culture, processes, and systems, requires effective change management to succeed (Cowan-Sahadath, 2010). Change management serves as a guiding mechanism to help individuals and teams navigate transitions, reduce resistance, and maximise benefits. Research underscores its critical role in shaping the outcomes of transformations. For example, studies by Sung and Kim (2021) indicate that effective change management practices mitigate resistance, enhance employee engagement, and foster a positive organisational culture.

The integration of digital technologies into change processes has also gained prominence. Recognising digital opportunities, regardless of an organisation's size, is pivotal for modern transformations. Digital platforms and technological advancements serve as key enablers, supporting organisational changes and enhancing their effectiveness (Pacolli, 2022; Robertson and De Vellis, 2023; Türk, 2023).

### 2.4 Research gap and theoretical framework

Recent literature has extensively documented the construction industry's digital transformation journey, the emergence of human-centric approaches, and the role of change management in organisational transitions (Chuang and Yang, 2023; Zhang *et al.*, 2023; Li

*et al.*, 2025). However, a critical gap exists in understanding how these elements intersect, particularly in implementing human-centric digital transformation within construction organisations. While studies have explored digital transformation challenges (Yang *et al.*, 2024) and human-centric principles (Bhatia *et al.*, 2023) separately, there is limited research examining how construction organisation leaders navigate the human aspects of digital transformation implementation. This study's unique contribution lies in its specific focus on leadership challenges in implementing human-centric digital transformation for Lean Construction 4.0, differentiating it from existing research that either addresses general digital transformation challenges (without lean context), lean construction implementation (without digital focus), or human-centric approaches (without construction industry specificity). By examining the intersection of these three domains from a leadership perspective, this research addresses an understudied area that is critical for successful industry transformation.

This gap is particularly significant given the construction industry's unique characteristics. Current research predominantly focuses on technological implementation aspects, with limited attention to human factors and change management considerations specific to construction organisations (Gledson *et al.*, 2024; K. Wang *et al.*, 2024; Qureshi, 2024; W. Wang *et al.*, 2024; You, 2024). Moreover, while theoretical frameworks exist for change management in digital transformation, these frameworks often fail to account for the construction industry's distinct workforce composition, project-based nature, and traditional work practices (Robertson and De Vellis, 2023).

The theoretical framework for this study is grounded primarily in change management theory, which provides the most comprehensive lens for examining how construction organisation leaders navigate the challenges of implementing human-centric digital transformation for Lean Construction 4.0. Change management theory encompasses the processes, strategies, and frameworks necessary for managing organisational transitions from current states to desired future states (Kotter, 1995; Hayes, 2006). This theory is particularly suited to our research context because it addresses the multi-dimensional nature of transformation challenges that construction leaders face, including cultural change, stakeholder engagement, resistance management, and capability development across complex organisational structures (Singh *et al.*, 2022).

While socio-technical systems theory and human-centred design principles offer valuable insights into human-technology integration and user-focused design respectively, change management theory provides the overarching framework that incorporates these perspectives while addressing the broader organisational transformation challenges specific to the construction industry's project-based, multi-stakeholder environment.

This theoretical framework guides our investigation of the challenges construction organisation leaders face when implementing human-centric digital transformation. By examining these challenges through the experiences of senior leaders, this study aims to bridge the gap between theoretical understanding and practical implementation of human-centric digital transformation in construction organisations. This research contributes to both theory and practice by providing insights into how construction organisations can more effectively manage the human aspects of digital transformation while addressing industry-specific challenges.

### 3. Research design and methods

#### 3.1 Research approach

This research employed a qualitative research design to investigate the challenges of implementing human-centric digital transformation in construction organisations. A qualitative approach was chosen due to the complex nature of organisational change and the need to understand rich, contextual insights from organisational leaders (Dodgson, 2017). The research followed an interpretive paradigm, acknowledging that understanding digital

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transformation challenges is socially constructed through the experiences and perspectives of industry practitioners (Myers, 2019).

While comprehensive change management encompasses multiple dimensions, including driving factors, impact assessment, and solution development, this study focuses specifically on the challenge identification phase, which represents the critical first step in developing effective change management strategies. Understanding the specific challenges construction organisation leaders face when implementing human-centric digital transformation provides the essential foundation for subsequent research phases that will address solution development and implementation strategies.

### 3.2 Sampling strategy

**3.2.1 Participant selection.** Purposive sampling was employed to select participants, ensuring representation from organisation leaders within the construction industry (Patton, 2014). Selection criteria included:

- (1) Minimum of 5 years of industry experience
- (2) Current leadership position in construction organisation
- (3) Direct involvement in digital transformation initiatives
- (4) Experience in change management implementation
- (5) Leadership experience in construction organisations implementing operational improvement initiatives

While lean construction experience was not an explicit selection criterion, the participant profile naturally included individuals with relevant lean construction exposure, given their senior leadership roles in progressive construction organisations. The construction industry's widespread adoption of lean principles means that experienced leaders in major construction organisations have typically encountered lean methodologies through organisational initiatives, project delivery methods, or industry best practices, even if not always formally designated as "lean construction" programs. The research team brings direct lean construction expertise, ensuring appropriate theoretical grounding and practical understanding of lean construction principles in the analysis and interpretation of findings.

The final sample comprised 20 senior organisation leaders, including CEOs, CIOs, CTOs, CHOs, Digital Engineering Leads, Project Delivery Managers, Change Managers and Technical Directors from New Zealand, Australia, the UK and Denmark. This sample size aligns with recommendations for qualitative organisational research, where 15–25 participants typically achieve theoretical saturation (Namey *et al.*, 2016).

**3.2.2 Participant profile.** Participants represented diverse experiences and perspectives, as shown in Figures 1 and 2:

Combined industry experience exceeded 390 years, with individual experience ranging from 5 to 50 years.

Regarding experience levels, two participants with less than 10 years of experience (P11: 5 years, P14: 8 years) were included because they held senior digital leadership roles in organisations undergoing active digital transformation. Their inclusion provides crucial perspectives on how younger leaders navigate traditional construction industry practices, offering insights into generational approaches to human-centric digital transformation that complement the perspectives of more experienced traditional leaders.

The details of participants are in the Table 1:

The concentration of participants from Australia and New Zealand reflects both practical accessibility considerations and these regions' established construction industries with ongoing digital transformation initiatives. While this geographical distribution limits direct generalisability to all global contexts, the focus on senior leadership challenges in

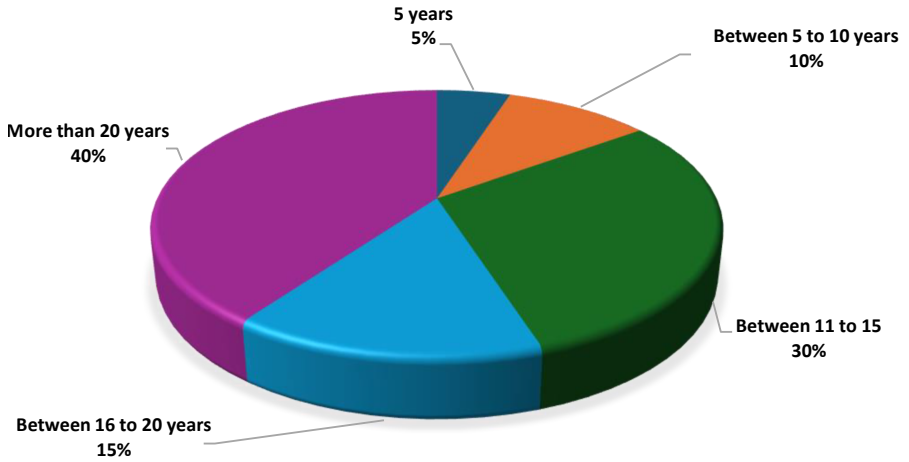


Figure 1. Participants' years of experience. Source: Authors' own work

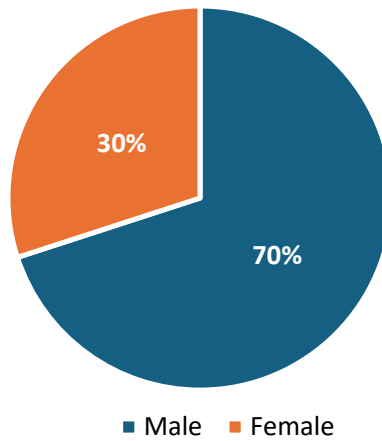


Figure 2. Participants' Gender. Source: Authors' own work

implementing human-centric digital transformation addresses fundamental organisational dynamics that are common across developed construction markets (Maskuriy *et al.*, 2019).

The inclusion of participants from the UK and Denmark adds European perspectives, representing different regulatory environments and construction practices. The identified challenges reflect human and organisational factors inherent to construction industry characteristics, project-based operations, traditional practices, and multi-stakeholder complexity, that are consistent across developed construction markets pursuing digital transformation.

### 3.3 Data collection

3.3.1 *Interview protocol development.* Semi-structured interviews were conducted following a protocol developed based on the research objectives and literature review (Kallio *et al.*, 2016). The interview guide was structured through systematic analysis of change management

**Table 1.** Participants information

Row	Role	Experience (Year)	Country
P1	Senior Lecturer	50	Australia
P2	Operational Excellence	20	New Zealand
P3	Technical Director	17	New Zealand
P4	Chief Information Officer	25	New Zealand
P5	Director–Digital Engineering	24	New Zealand
P6	Project Manager	10	New Zealand
P7	Head of People and Capability	11	New Zealand
P8	General Manager	14	New Zealand
P9	Tech General Manager	25	New Zealand
P10	Regional Sales Manager	15	New Zealand
P11	Digital Engineer	5	New Zealand
P12	Head of IT–Construction	19	New Zealand
P13	Transformation Manager	21	New Zealand
P14	BA and Change Practice Manager	8	New Zealand
P15	Principal–Systems Engineering	21	New Zealand
P16	Senior Digital Project Manager	15	Australia
P17	Service Lead–Project Delivery	14	Australia
P18	Digital Delivery Lead	11	Australia
P19	Self-Employment	23	UK
P20	CEO & Founder	44	Denmark

activities from literature. A focused literature review of ten established change management models were conducted including: Kotter’s 8-Step Process (Kotter, 1995), Lewin’s 3-Stage Model (Juneja, 2020), ADKAR Model (Ali *et al.*, 2021), Bridges Transition Model (Miller, 2017), McKinsey 7-S Framework (Etareri, 2022), Bullock and Batten’s Change Model (Bullock and Batten, 1985), Mento *et al.*’s Change Model (Mento *et al.*, 2002), Kickert (2013), Change Formula of Beckhard and Harris (Beckhard and Harris, 1987), and Change Management Body Of Knowledge (Smith, 2015). Then the core change activities from each model have been extracted and mapped, identifying recurring themes across frameworks. Finally, we consolidated overlapping activities into ten distinct change management areas that appeared consistently across multiple models. The ten challenge areas investigated (strategic vision and communication, organisational competencies assessment, training and development, resource allocation, employee involvement and empowerment, value integration, technological adoption, performance monitoring and feedback, well-being and support structure, and cultural reinforcement) represent the core change management activities extracted from established change management models rather than generic organisational challenges. This analysis identified key areas for investigation, which were structured into three phases: contextualisation, investigation of change management challenges, and reflection. The protocol was validated through expert review and pilot testing (Kallio *et al.*, 2016). Questions specifically addressed construction industry characteristics while maintaining alignment with change management theory.

Interviews were conducted between September and December 2024, lasting 60–90 minutes each. Interviews were conducted via video conferencing platforms, recorded with participant consent, and transcribed verbatim. Following Gibbs’s recommendations for qualitative data quality, transcripts were sent to participants for verification (Marcotte and Allard, 2018).

### 3.4 Data analysis

**3.4.1 Analytical approach.** A systematic thematic analysis approach was adopted following Braun and Clarke’s six-phase framework (Braun and Clarke, 2006):

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- (1) Familiarisation with data
  - (2) Initial coding
  - (3) Theme development
  - (4) Theme review
  - (5) Theme definition
  - (6) Report production
- 

NVivo software was used to support the coding process, enabling systematic organisation and analysis of the qualitative data (Bazeley and Jackson, 2013).

3.4.2 *Coding process.* The coding process involved multiple cycles (Gioia *et al.*, 2013):

First cycle coding utilised both deductive codes derived from the ten change management models identified in the literature review and inductive codes emerging from participant responses. Deductive codes included predetermined categories such as “vision communication,” “resource allocation,” and “training challenges,” while inductive codes captured construction-specific themes such as “profit margin constraints,” “generational resistance,” and “joint venture complexity.”

Second cycle pattern coding identified relationships and clusters among initial codes, revealing how individual challenges interconnected across the ten change management areas. For example, codes related to “digital literacy gaps,” “training costs,” and “productivity loss during training” were grouped under the broader pattern of “training and development challenges.”

Third cycle theoretical coding connected empirical findings to existing change management literature while identifying construction industry-specific variations. This process revealed how established change management challenges manifest differently in construction contexts, such as how “resource allocation” challenges are intensified by the industry’s low profit margins and project-based structure.

NVivo software supported systematic organisation and analysis of qualitative data. The software enabled: (1) systematic coding across all 20 transcripts with consistency tracking, (2) pattern identification through query functions and coding comparisons, (3) theme development through hierarchical node structures, and (4) evidence compilation through coded reference retrieval for theme validation. 3.4.3. *Validation Strategies.*

Several validation strategies were employed to ensure research rigour (Buchbinder, 2011; Creswell and Poth, 2016): member checking involved sending transcripts to participants for verification; peer debriefing with research supervisors provided external perspective on coding decisions; thick description with extensive supporting quotes maintained contextual richness; audit trail documentation recorded all analytical decisions and their rationale; and researcher reflexivity documentation acknowledged potential biases and their management throughout the analysis process. The validation process yielded the following results: Member checking resulted in 20 out of 20 participants confirming transcript accuracy. Peer debriefing sessions with research supervisors identified no major concerns with coding decisions, though minor refinements were made to theme definitions for clarity. The audit trail documentation enabled verification of analytical decisions, with no inconsistencies identified in the coding process. Researcher reflexivity documentation revealed potential bias toward digital transformation benefits, which was addressed through enhanced attention to participant concerns and resistance themes during analysis.

### 3.5 *Ethical considerations*

The research received ethical approval. Participant anonymity and confidentiality were maintained through the use of pseudonyms and the removal of identifying information. Data storage and handling followed institutional guidelines for research data management.

#### 4. Results and analysis

This section presents a systematic analysis of the challenges identified by 20 senior organisational leaders in implementing human-centric digital transformation in construction organisations. The interview process followed a three-phase structure designed to systematically explore participants' experiences and insights regarding human-centric digital transformation in construction organisations:

Phase One focused on contextualisation and problem identification. This initial phase introduced participants to the research scope and explored their understanding and experience with digital transformation initiatives. Participants were encouraged to reflect on implementation challenges they had encountered and potential solutions they had developed or observed in their organisations.

Phase Two employed a structured interview approach centred on change management theory and implementation. The initial analysis framework was informed by critical areas of human-centric transformation implementation identified in previous literature (Kotter, 2009; McKinsey, 2018; Leclerc *et al.*, 2020; Lugonja, 2020; Errida and Lotfi, 2021; Laig and Abocejo, 2021). Through systematic thematic analysis of the interview data, these areas were further validated and refined based on participants' responses, with challenges naturally clustering around key implementation aspects of Strategic Vision and Communication, Organisational Competencies Assessment, Training and Development, Resource Allocation, Employee Involvement and Empowerment, Value Integration program, Technological Adoption, Performance Monitoring and Feedback, Well-being and Support Structure and Cultural Reinforcement. Participants were systematically questioned about specific challenges organisational leaders face at each stage of implementation. This phase was particularly focused on identifying barriers and obstacles across the change management activities.

Phase Three provided an opportunity for reflection and synthesis. Participants were invited to offer additional insights, clarify previous responses, and provide concluding thoughts on the overall challenges of implementing human-centric digital transformation. This phase allowed for the emergence of themes or considerations that might not have been captured in the more structured portions of the interview, enriching the overall data collection.

The ten challenge areas examined correspond directly to core change management activities identified in the literature review. These areas represent established change management domains contextualised for Lean Construction 4.0 implementation challenges.

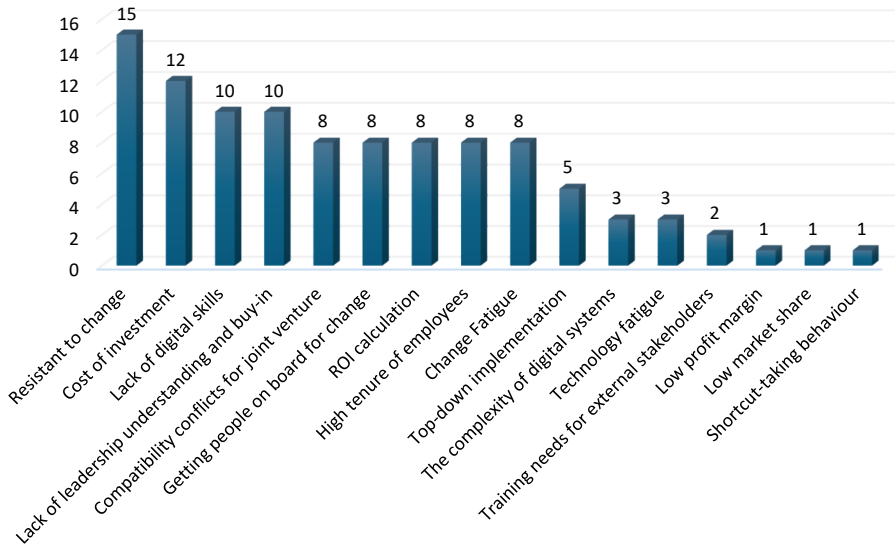
##### *4.1 Overview, concepts and challenges of digital transformation in the construction industry*

As mentioned earlier, to familiarise the participants with the topic and prepare them for the second part of the interview, after introducing themselves, they were asked the question, "What challenges or barriers have you encountered in implementing a digital transformation in the construction industry?"

As can be seen from Figure 3 and the following quotes from the participants in the study, it is clear that the general challenges they mentioned are very similar to those from the literature:

Interview excerpts are presented with participant identifiers (e.g. P1, P2) to maintain anonymity while enabling traceability of responses across themes.

"Long-tenured employees, particularly those with 20–30 years of experience, exhibit significant resistance to new systems due to their reliance on memorised processes and institutional knowledge. The transition from internalised knowledge to documented systems presents a particular challenge for older workers who have developed ingrained work habits over decades of service. This resistance is notably stronger among employees in their 50s and 60s compared to younger workers in their 20s and 30s, who demonstrate greater adaptability to new systems." (P4)



**Figure 3.** Digital transformation implementation challenges. Source: Authors' own work

Digital transformation requires substantial upfront investment in complete software systems that cannot be partially implemented. Given the construction industry's typically low-profit margins of 4–6%, organisations must generate significant additional revenue just to break even on their technology investments. This 'lumpy asset' problem, where technology must be purchased as a complete package rather than incrementally, creates a significant financial barrier to digital adoption. (P1)

A fundamental challenge in digital transformation is the widespread lack of digital literacy in the construction industry. Organisations often seek to implement advanced digital solutions and standards, such as ISO 19650, without having the foundational knowledge and understanding of these systems. This knowledge gap creates a significant barrier to effective digital adoption and implementation. (P10)

A critical barrier to digital transformation is the lack of technological literacy among organisational decision-makers. When leadership lacks even basic understanding of digital technologies and their potential opportunities, it significantly impedes the implementation of digital initiatives. Effective digital transformation requires leaders who not only sponsor initiatives but possess sufficient technological comprehension to make informed strategic decisions. (P9)

In joint venture projects, conflicting software preferences between partner organisations create significant implementation challenges. When different organisations are trained and experienced in different platforms (such as Civil 3D versus Tekla), selecting a unified system becomes problematic. This incompatibility not only creates operational conflicts but also demands additional time and resources to retrain staff and establish standardised workflows across the joint venture. (P3)

A major obstacle to digital transformation is the difficulty in securing dedicated time for change management activities. With employees fully engaged in project deliverables, finding additional time for training, upskilling, and migration to new systems becomes problematic. This challenge is exacerbated by the tendency to view change management activities as secondary to immediate project demands rather than as essential organisational investments. (P6)

#### 4.2 Challenges of implementing digital transformation in the change management stages

As previously mentioned, in the second phase of the interview, challenges associated with each stage of change management were identified. The following is a separate examination of the challenges in each stage.

**4.2.1 Strategic vision and communication challenges.** In the first question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you anticipate in creating and communicating a strategic vision of implementing human-centric digital transformation effectively?”

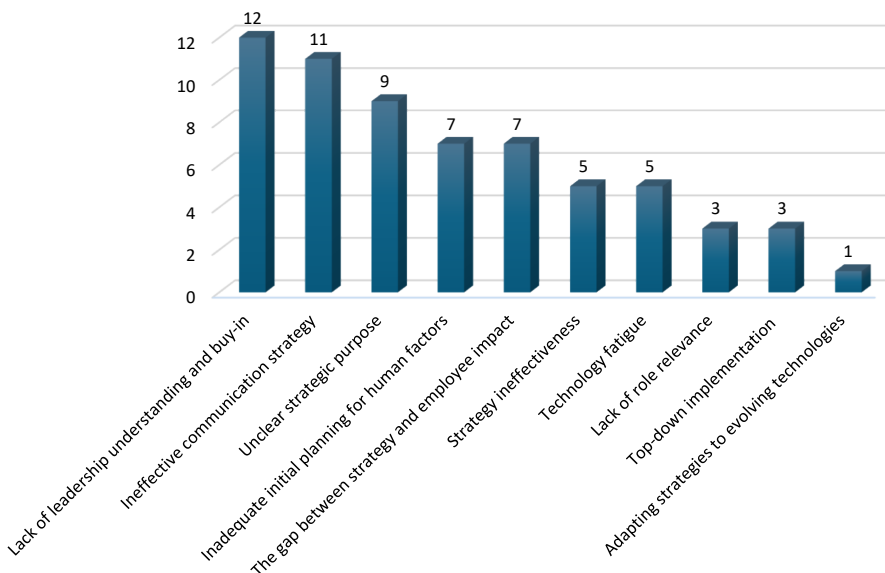
According to the analysis of the results of the participants’ answers in the study in Figure 4, the participants raised issues, quotes from which are given below.

The success of digital transformation initiatives critically depends on authentic leadership commitment and vision. When leadership’s support is perceived as superficial, or their understanding of the transformation journey is unrealistic, it significantly undermines stakeholder buy-in. A strategic vision that fails to authentically acknowledge the gap between current and desired organisational states or that is poorly communicated leads to increased internal resistance and compromises the entire transformation process. (P15,8,2)

The lack of clear communication strategy in digital transformation creates cascading effects throughout the organisation. When implementation requirements and expectations are not effectively communicated, it leads to widespread misunderstanding among stakeholders, resulting in project delays and delivery challenges. These communication breakdowns, once established, become increasingly difficult to rectify and can fundamentally undermine the transformation process. (P10,9)

These challenges reflect construction’s hierarchical culture where leadership credibility depends heavily on experiential knowledge, making digital transformation vision particularly vulnerable to authenticity concerns.

**4.2.2 Organisational competencies assessment challenges.** In the second question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you foresee in accurately assessing organisational competencies for digital transformation implementation?”



**Figure 4.** Strategic vision and communication challenges. Source: Authors’ own work

According to the analysis of the results of the participants’ answers in the study in Figure 5, the participants raised issues, quotes from which are given below.

Organisations face significant challenges in accurately measuring employee competencies due to the lack of standardised assessment metrics and consistent evaluation methods. Without regular data-gathering mechanisms and robust mentorship programs in place, it becomes difficult to gauge workforce capabilities and track progress over time reliably. (P6,20)

The construction industry’s diverse workforce, comprising multiple trades and specialisations, makes it challenging to develop standardised competency metrics. Each role requires different skill sets and expertise, making it complex to create comprehensive assessment frameworks that can effectively evaluate capabilities across various disciplines. (P11)

Organisations often lack clear benchmarks and reference models for digital transformation, making it difficult to establish performance targets or assess their current state. They struggle to identify gaps in their capabilities and determine appropriate improvement strategies without understanding what ‘good’ looks like.” (P1,15)

The assessment complexity stems from construction’s diverse trade-based workforce requiring different digital competencies, unlike industries with more homogeneous skill requirements.

4.2.3 *Training and development challenges.* In the third question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you anticipate in delivering effective training across different roles and skill levels?”

According to the analysis of the results of the participants’ answers in the study in Figure 6, the participants raised issues, quotes from which are given below.

Training effectiveness is challenged by diverse learning preferences and generational differences among employees, requiring organisations to develop flexible and multi-modal training approaches. A one-size-fits-all training strategy is ineffective, as individuals vary significantly in their preferred learning methods and comfort with different training formats. (P12,13,4,5)

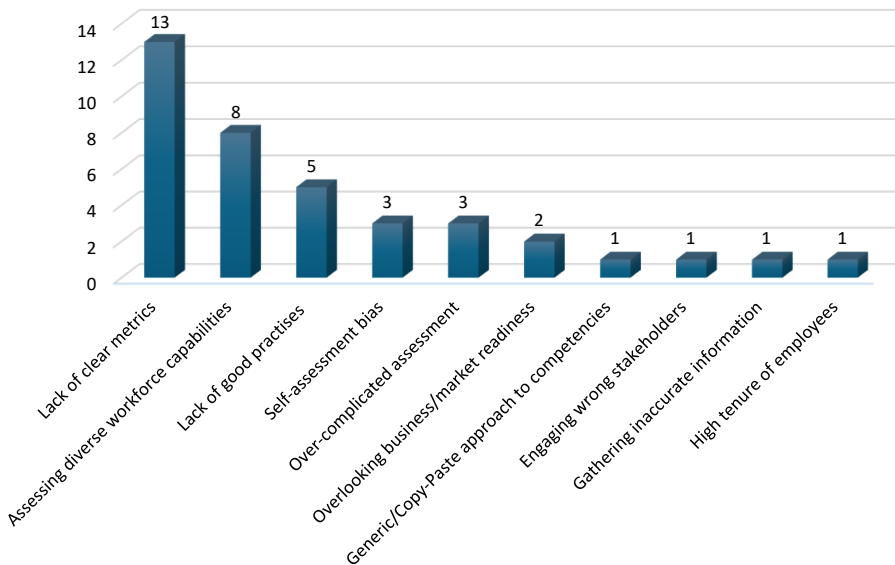
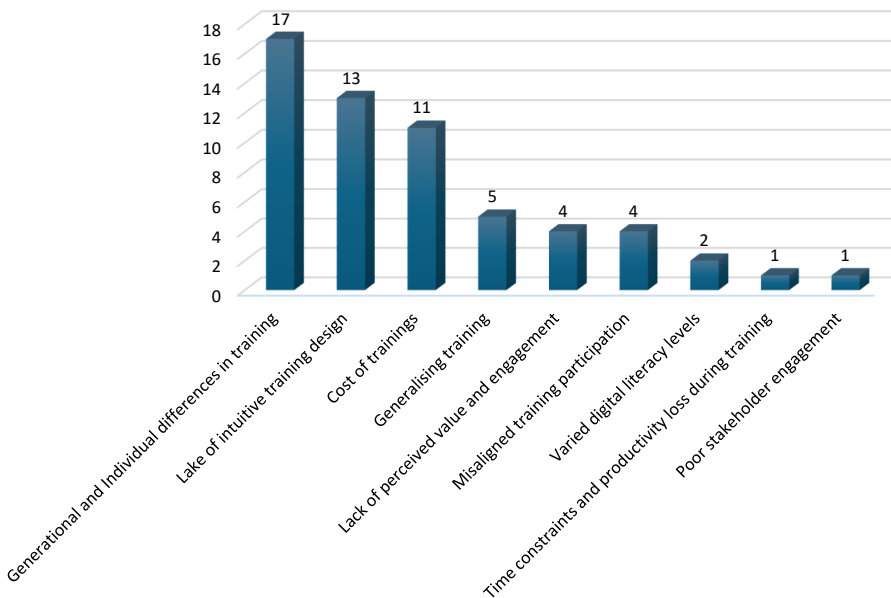


Figure 5. Organisational competencies assessment challenges. Source: Authors’ own work



**Figure 6.** Training and development challenges. Source: Authors' own work

Training adoption is significantly impacted by the intuitiveness of software design. When tools lack user-friendly interfaces and clear workflow processes, they create additional learning barriers and require more intensive training effort. Conversely, intuitive designs that guide users through tasks step-by-step reduce training complexity and increase user acceptance. (P1,15,20)

Organisations face significant financial challenges in implementing training programs, not only from direct training costs but also from the indirect costs of lost productivity when employees are taken away from their regular duties. This dual cost burden often influences decisions about training scope and delivery methods. (P7,18)

These challenges are amplified by construction's project-based nature where training time directly conflicts with productivity demands, creating unique implementation pressures.

**4.2.4 Resource allocation challenges.** In the fourth question of the second part of the interview protocol, the participants in the study were asked to answer the question, "What challenges do you foresee in securing and distributing sufficient resources effectively?"

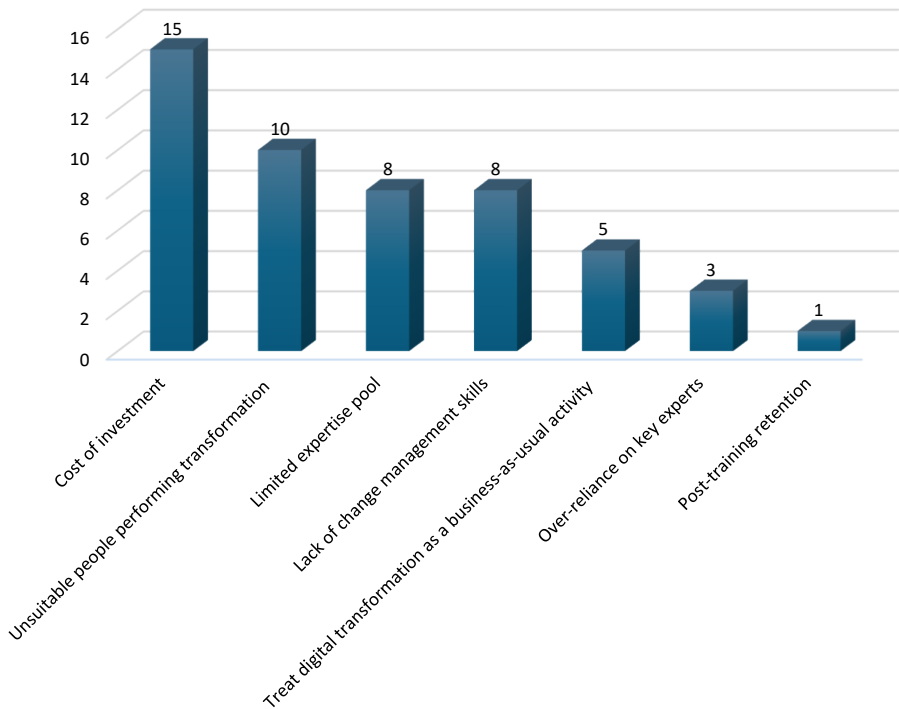
According to the analysis of the results of the participants' answers in the study in [Figure 7](#), the participants raised issues, quotes from which are given below.

Organisations often view digital transformation initiatives as non-essential expenditure, leading to reduced investment in critical components like change management and training in an effort to minimise costs while maintaining basic technological functionality. (P14,11,4)

Digital transformation initiatives can be undermined when led or implemented by personnel who are sceptical or disengaged, as their lack of commitment affects implementation effectiveness regardless of resource allocation. (P20,16,15)

The construction industry faces a significant shortage of digital expertise, as the sector has historically lagged behind other industries in technological adoption, resulting in limited availability of professionals with the necessary digital capabilities. (P17,8)

Construction's traditionally low profit margins (4–6%) intensify resource allocation challenges compared to higher-margin industries implementing digital transformation.



**Figure 7.** Resource allocation challenges. Source: Authors' own work

**4.2.5 Employee involvement and empowerment challenges.** In the fifth question of the second part of the interview protocol, the participants in the study were asked to answer the question, "What challenges do you anticipate in achieving meaningful employee involvement and empowerment in the process of implementing digital transformation?"

According to the analysis of the results of the participants' answers in the study in [Figure 8](#), the participants raised issues, quotes from which are given below.

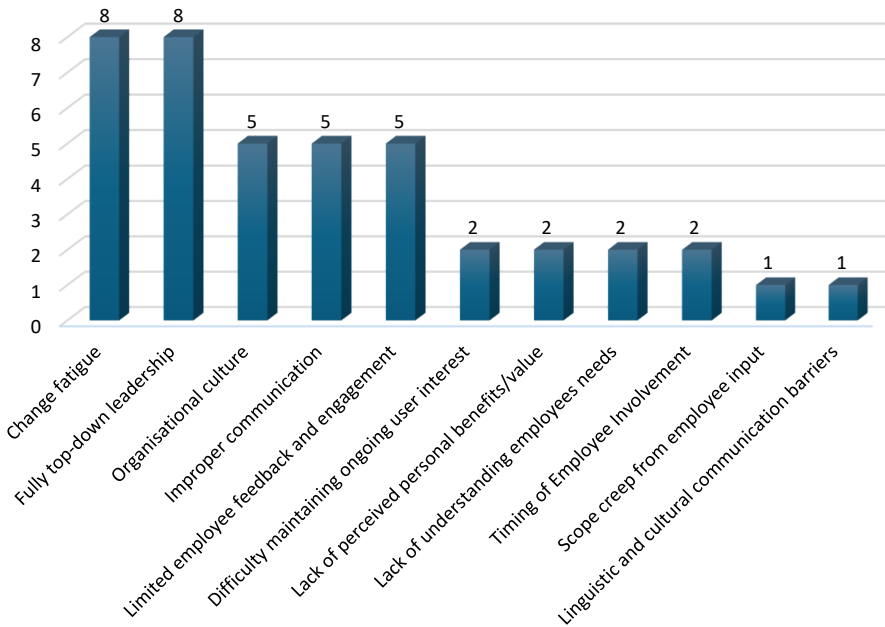
Organisations face significant challenges with change fatigue, where the cumulative impact of multiple simultaneous changes, both professional and personal, diminishes employees' capacity and willingness to engage with new digital initiatives. (P5,13)

A purely top-down approach to digital transformation, where changes are mandated without grassroots engagement, proves ineffective in modern commercial organisations, particularly as workforce mobility increases and employee buy-in becomes more critical to successful implementation. (P15,19)

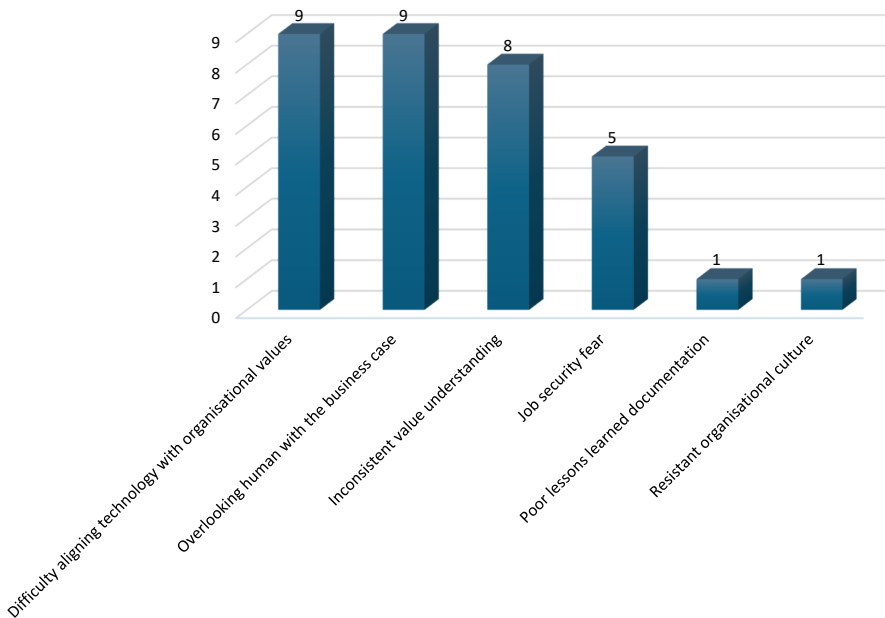
The construction industry's mobile workforce and project-based employment patterns complicate sustained employee engagement efforts typical in permanent organisational settings.

**4.2.6 Value integration challenges.** In the sixth question of the second part of the interview protocol, the participants in the study were asked to answer the question, "What challenges do you foresee in aligning digital transformation implementation with human-centric values and organisational values?"

According to the analysis of the results of the participants' answers in the study in [Figure 9](#), the participants raised issues, quotes from which are given below.



**Figure 8.** Employee involvement and empowerment challenges. Source: Authors' own work



**Figure 9.** Value integration challenges. Source: Authors' own work

Organisations struggle to meaningfully connect technological implementations with their core values and human-centric principles, often viewing digital transformation merely as a toolset rather than an organisational culture change. (P9,12)

They prioritise technical and financial aspects in their business cases for digital transformation while failing to adequately address human factors such as employee value, loyalty, and engagement as core components of the implementation strategy. (P4,11)

It's hard to effectively communicate and demonstrate the personal value proposition of digital transformation to stakeholders at different levels, leading to inconsistent understanding and buy-in across the organisation. (P7,13)

This disconnect reflects tension between lean construction's human-centric values and perceived technology-centric focus of digital transformation initiatives.

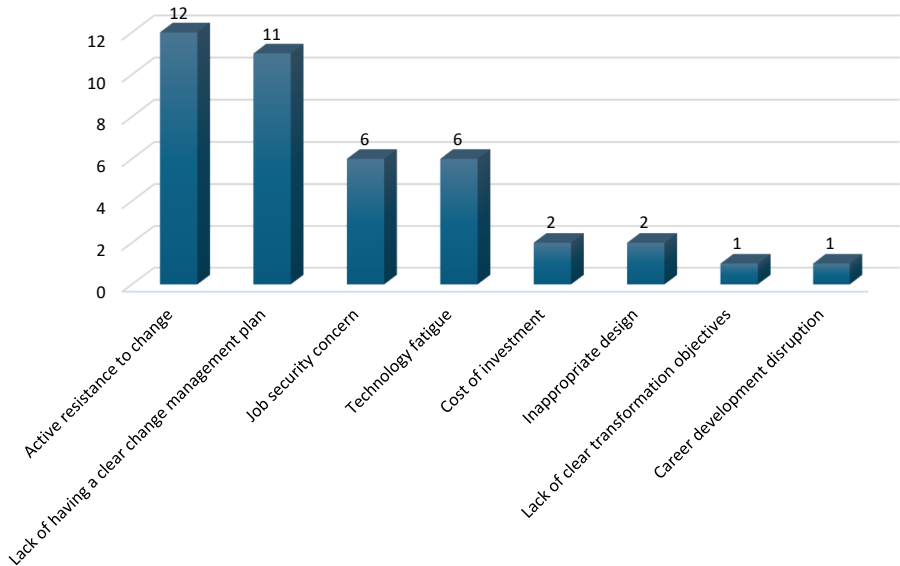
4.2.7 *Technological adoption challenges.* In the seventh question of the second part of the interview protocol, the participants in the study were asked to answer the question, "What challenges do you anticipate in ensuring that technology enhances rather than replaces human roles and technology adoption?"

According to the analysis of the results of the participants' answers in the study in [Figure 10](#), the participants raised issues, quotes from which are given below.

Active resistance to digital transformation manifests through employees' deliberate opposition to change, often following a cycle of denial, anger, and eventual acceptance, with some individuals actively undermining implementation by falsely reporting technical failures or creating other obstacles. (P2,3,6,9)

Organisations often implement digital transformation without a comprehensive change management plan that aligns with existing work practices, leading to unnecessary complications in technological adoption that could be mitigated through a better understanding of employee workflows. (P17,18)

Resistance patterns follow construction's traditional change cycles, where manual process expertise creates stronger opposition to digital alternatives than in other industries.



**Figure 10.** Technological adoption challenges. Source: Authors' own work

**4.2.8 Performance monitoring and feedback challenges.** In the eighth question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you foresee in establishing effective monitoring and feedback mechanisms?”

According to the analysis of the results of the participants’ answers in the study in **Figure 11**, the participants raised issues, quotes from which are given below.

Effective performance metrics remain a challenge, as benchmarking often falls short due to the unique nature of projects and programs. While internal benchmarking can provide insights such as measuring time savings for specific tasks, it’s difficult to generalise results across different contexts. Capturing and monitoring performance consistently remains a complex and critical issue. (P16)

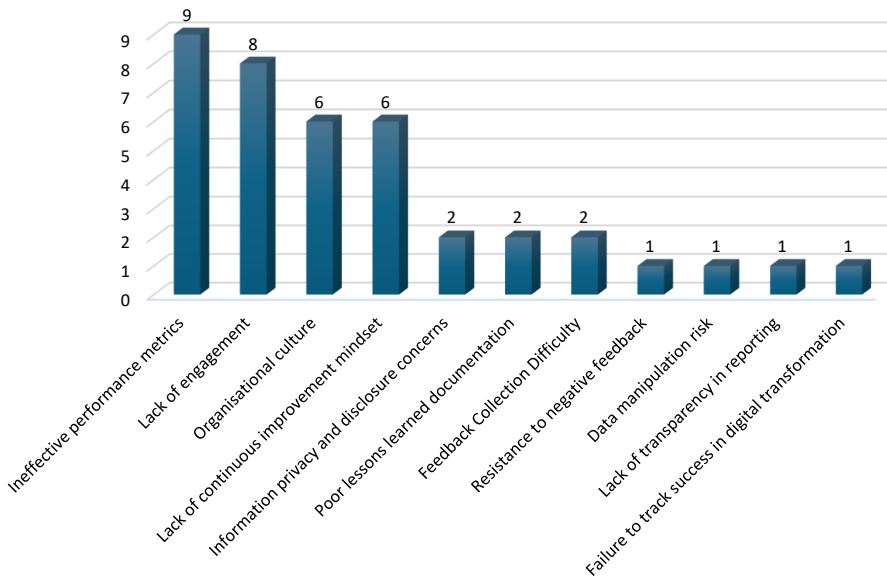
A significant challenge is the lack of active engagement, as individuals often refrain from providing feedback due to being too busy or feeling frustrated. While feedback, both positive and negative, is valued, the current mechanisms for collecting and organising it are inadequate and need improvement to foster better communication and participation. (P12,20)

Construction’s project uniqueness and temporary organisational structures complicate performance benchmarking compared to continuous operations in other industries.

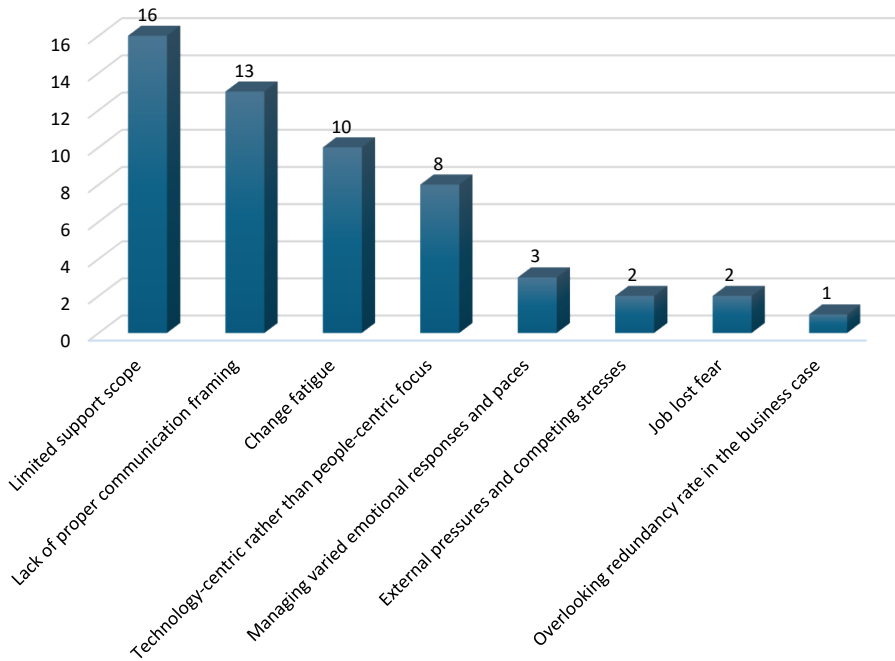
**4.2.9 Well-being and support structure challenges.** In the ninth question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you anticipate in addressing the potential stress and disruption caused by this implementation?”

According to the analysis of the results of the participants’ answers in the study in **Figure 12**, the participants raised issues, quotes from which are given below.

Support structures during periods of change often fail to account for the time needed for individuals to adapt, process, and plan for future shifts. Without authentic and well-designed strategies that address long-term impacts, individuals may struggle to upskill or pivot effectively. This lack of comprehensive support undermines their ability to make informed choices about their evolving roles. (P7,8,13,18)



**Figure 11.** Performance monitoring and feedback challenges. Source: Authors’ own work



**Figure 12.** Well-being and support structure challenges. Source: Authors' own work

The way messages are framed significantly impacts how they are received. For instance, emphasising doing “more with the same number of people” and highlighting a shift toward more meaningful tasks rather than tedious ones can foster a more positive response. Poor communication framing can lead to misunderstandings and resistance to change. (P1,11)

Support structure challenges are intensified by construction’s physically demanding environment and traditional masculine culture that may discourage help-seeking behaviours.

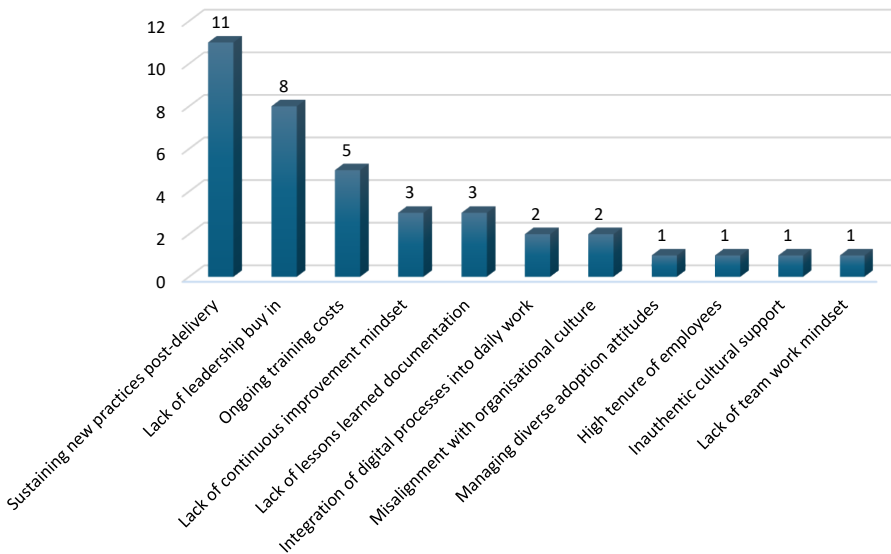
**4.2.10 Cultural reinforcement challenges.** In the tenth question of the second part of the interview protocol, the participants in the study were asked to answer the question, “What challenges do you foresee in embedding the technology-related change into the organisational culture?”

According to the analysis of the results of the participants’ answers in the study in **Figure 13**, the participants raised issues, quotes from which are given below.

Sustaining momentum and alignment post-delivery is challenging, as people may revert to old habits once the project ends. Clear and consistent communication is essential to reinforce expectations regarding behaviours and practices, ensuring long-term adherence to desired changes. (P9,13)

Successful implementation requires active involvement and commitment from senior leadership. Without leadership’s passion and accountability, such as tracking and measuring the adoption of new tools, initiatives risk being ignored or underutilised, leading to wasted efforts and resources. (P14,2)

Training costs escalate when addressing diverse systems and processes used by employees from different backgrounds. Transitioning to a unified system requires tailoring training to acknowledge previous practices, which often means managing multiple variations and troubleshooting needs. For organisations with a large workforce, this complexity significantly increases the effort and resources required for effective training. (P20)



**Figure 13.** Cultural reinforcement challenges. Source: Authors' own work

Cultural reinforcement faces unique challenges in construction's project-based environment, where teams dissolve after project completion, disrupting continuity of change efforts.

## 5. Discussion

This study highlights the challenges construction organisation leaders face when implementing human-centric digital transformation to enable Lean Construction 4.0. The results demonstrate that while technological advancement is crucial, the human aspects of digital transformation present the most significant challenges. This aligns with existing research, which identifies organisational culture, leadership engagement, and change resistance as central barriers to digital adoption (Robertson and De Vellis, 2023; Gledson *et al.*, 2024). However, our findings contribute further by revealing how these challenges manifest specifically in the construction sector's journey toward Lean Construction 4.0.

The participants' experiences reveal that resistance to change isn't simply about reluctance to adopt new technologies; rather, it stems from deeply ingrained work practices and institutional knowledge accumulated over decades. This is particularly evident in the challenge of transitioning from memorised processes to documented systems, especially among long-tenured employees. Similar challenges have been identified in other industries undergoing digitalisation, such as manufacturing, where workforce retraining has been critical to success (Jamwal *et al.*, 2021).

The findings also reveal that construction firms often struggle with limited financial capacity for digital transformation. The industry's traditionally low-profit margins (4–6%) hinder investment in full-scale digital systems. This is consistent with Wang *et al.* (2024), who argue that financial constraints remain a major impediment to technological adoption in capital-intensive sectors.

The study also illustrates gaps in organisational competency assessment frameworks. While previous studies have emphasised the importance of capability assessment, our findings reveal specific challenges in evaluating competencies across diverse construction trades and specialisations. The industry's unique workforce composition, combining traditional craft skills with emerging digital requirements, creates unprecedented complexity in assessment

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frameworks. This is further complicated by the high staff turnover rate (approximately 20% annually), which necessitates continuous training and knowledge transfer efforts.

Leadership also plays a big role in the success of digital transformation and lean implementation. The findings show that leaders who don't understand digital technologies and their potential benefits can slow down progress. For Lean Construction 4.0 to succeed, leaders need to not only support these efforts but also have sufficient knowledge to make informed decisions and guide their teams effectively. This aligns with [Bianco et al. \(2021\)](#), who emphasise that leadership understanding and commitment are critical success factors for Lean Construction 4.0 implementation.

Finally, the research shows the challenges of maintaining a human-centric focus during digital transformation. Organisations often struggle to meaningfully connect technological implementations with their core values and human-centric principles, frequently viewing digital transformation merely as a toolset rather than an organisational culture change. This disconnect between technical implementation and human values extends beyond the general challenges identified in previous studies and appears particularly acute in the construction context.

To successfully implement Lean Construction 4.0, organisations need strategies that address the specific challenges of their industry while keeping people at the centre of their efforts. This means focusing on leadership development, workforce training, and aligning digital changes with the organisation's values and culture. Future studies could explore how to improve skills assessments, develop better training programs, and support leaders in combining technical and human-centred approaches.

The findings have significant implications for both theory and practice. Theoretically, this study extends change management frameworks by demonstrating how construction industry characteristics, including project-based operations, high staff turnover, and traditional work practices, create unique digital transformation challenges. For practitioners, the results highlight specific barriers including low profit margins limiting technology investment, resistance from long-tenured employees transitioning from memorised to documented processes, and the challenges of maintaining productivity during training periods. These industry-specific challenges require targeted solutions that balance technological advancement with human factors. The ten identified challenge areas provide construction organisation leaders with a diagnostic framework for implementing Lean Construction 4.0 transformation. Leaders can use these challenges to assess organisational readiness, for example, evaluating workforce digital literacy levels before technology implementation, or conducting resource capacity analysis that accounts for construction's low profit margins. The interconnected nature of challenges, such as how resource constraints directly affect training quality and subsequently impact cultural adoption, enables leaders to anticipate cascading effects and develop targeted interventions. This framework addresses the gap between theoretical change management approaches and the specific requirements of construction industry transformation.

## 6. Conclusion

This research provides comprehensive insights into the challenges construction organisation leaders face when implementing human-centric digital transformation to enable Lean Construction 4.0. Through analysis of interviews with 20 senior leaders across multiple countries, the study reveals how the construction industry's unique characteristics create distinct barriers to digital transformation that require specific attention and tailored solutions.

The findings identify many challenge areas that organisation leaders must address, from strategic vision and communication to cultural reinforcement, all of which significantly impact the successful implementation of Lean Construction 4.0. These challenges are interconnected and must be addressed holistically rather than in isolation. The study demonstrates that successful implementation of Lean Construction 4.0 requires more than technological

implementation; it demands a careful balance between technological advancement and human factors, particularly given the industry's traditionally low-profit margins and high staff turnover rates.

For practitioners, it offers valuable insights for improving implementation of Lean Construction 4.0, emphasising the importance of authentic leadership commitment, clear strategic communication, and industry-specific competency assessment frameworks. This research lies in providing construction organisation leaders with a theoretically grounded, industry-specific framework for diagnosing, planning, and managing human-centric digital transformation initiatives. Unlike generic change management models, this framework addresses the unique constraints and characteristics of construction organisations, enabling more effective change implementation approaches that balance technological advancement with lean construction's human-centric principles.

Given the exploratory nature of human-centric digital transformation in construction organisations pursuing Lean Construction 4.0, this study adopted a qualitative approach through senior leader interviews to develop deep insights into implementation challenges. While this approach provided rich contextual understanding, future research could employ quantitative methods with larger sample sizes to validate these findings across broader industry contexts. Additionally, studies incorporating perspectives from multiple organisational levels could further enrich understanding of these challenges. Future research could explore specific strategies for addressing the identified challenges. While digital transformation presents significant challenges for construction organisations, success is achievable through careful attention to human factors and industry-specific considerations.

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