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Human-centric integrated change management framework for digital transformation in construction

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Abstract

Purpose – This study develops a human-centric change management framework to address the gap between building information modelling (BIM) potential and its practical implementation and adoption in the construction industry by focusing on human factors influencing digital transformation success.
Design/methodology/approach – A multi-phased methodology was employed, combining systematic literature reviews with advanced network analysis techniques. Two literature review rounds extracted key change management activities and human-centric principles. Social network analysis (SNA) was utilised to quantify relationships and significance within the construction industry context, identifying high-centrality nodes in the network.
Findings – The analysis identified training, organisational competency assessment and resource allocation as the most critical change management activities for successful digital transformation, which emerged as central nodes. The study developed a tailored three-phase framework (Strategic initialisation, Operational transformation and Sustainable integration) that enables construction organisations to implement BIM and digital technologies while maintaining focus on human factors. Practical implications include improved employee engagement, reduced resistance to technological change, enhanced organisational readiness for digital transformation and a structured pathway for construction organisations to move beyond current BIM implementation barriers. The framework provides actionable guidance for construction leaders to balance technological advancement with human-centric values, ultimately supporting sustainable digital transformation in the industry.
Originality/value – This study offers a novel data-driven approach to digital transformation in construction by quantitatively analysing relationships between change management activities and human-centric principles. The research addresses a critical gap in BIM and digital transformation implementation literature by developing an integrated framework that balances technological advancement with human considerations, helping organisations move beyond current adoption barriers in the AECO industry's transformative journey.

Keywords Organisational change management, Human centred organisation, Digital transformation, BIM implementation, Human-centric principles

Paper type Research article

1. Introduction

The concept of Industry 4.0, often referred to as the "fourth industrial revolution," marks a significant transformation in the integration of production processes with advanced

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information technologies, such as cyber-physical systems, the Internet of Things (IoT), artificial intelligence (AI), and data analytics (Nowotarski and Paslawski, 2017). This revolution is characterised by increased automation and digitisation of industries, resulting in enhanced efficiency, productivity and innovation (Bradu *et al.*, 2022; Qureshi, 2024). Although these advancements have transformed various sectors, the construction industry, traditionally reliant on manual labour and conventional methods, has been slower to adopt Industry 4.0 technologies (Maskuriy *et al.*, 2019). The adoption of such technologies within construction, often termed "Construction 4.0," remains in its early stages, with the pace of transformation varying significantly across regions due to differing levels of governmental support and industry enthusiasm (Timchuk *et al.*, 2021; Wang *et al.*, 2025).

As the construction industry begins to embrace digital transformation, a critical issue arises: How can construction organisations incorporate human-centric approaches into their digital transformation strategies? While Industry 4.0 technologies promise enhanced efficiency and automation, the construction industry faces unique challenges in balancing technological innovation with the human elements of the workforce. Creativity, emotional intelligence, and cognitive flexibility, as the key human attributes, are essential for driving sustainable and inclusive growth within this evolving digital landscape (Veling, 2014; Bidhendi and Poshdar, 2024; Townsend, 2024). However, as governments increase investments and revise legislation to encourage automation from project initiation to building management (Lat *et al.*, 2021), there is a growing concern that human-centric principles could be overshadowed by the focus on digital and AI-driven efficiency (Zizic *et al.*, 2022; Ghobakhloo *et al.*, 2024; Li *et al.*, 2025).

Despite significant investments in Building Information Modelling (BIM) and associated digital technologies, many construction organisations continue to struggle with successful implementation and integration (Munir *et al.*, 2021; Boontae and Ussavadilokrit, 2024; Kordestani Ghalenoei *et al.*, 2024). While technical barriers to BIM adoption have been extensively studied, the human and organisational dimensions that significantly impact implementation success have received less attention (Chowdhury *et al.*, 2024; Moradi and Sormunen, 2024; Huang *et al.*, 2025; Soman *et al.*, 2025). The gap between BIM's technological potential and its practical implementation highlights the need for a more comprehensive approach that addresses both technical and human factors.

Recent industry data highlights the extent of this implementation gap. While the global BIM market was valued at $8.12bn in 2024 and is projected to reach $22.08bn by 2032 (Fortune Business Insights, 2024), adoption rates reveal significant challenges. In developing countries such as India, surveys indicate that high hardware costs, high software costs, and low adoption across the supply chain constitute the top barriers to BIM pre-adoption (Mishra *et al.*, 2024). Post-adoption challenges are equally concerning, with ongoing costs, shortage of skills and expertise, and unclear benefit evaluation hindering sustained implementation (Mishra *et al.*, 2024). A comprehensive study of Malaysian construction professionals revealed that BIM-related challenges include knowledge gaps, infrastructure limitations, and modelling complexities, while project-related challenges encompass funding constraints, communication barriers, and coordination issues (Radzi *et al.*, 2025). Furthermore, approximately 40% of small and medium-sized construction firms cite financial constraints as the primary barrier to BIM integration, with training requirements representing another significant hurdle (Global Growth Insights, 2024). These statistics underscore a critical paradox: while technological capabilities continue to advance, human and organisational factors remain the primary impediments to realising BIM's transformative potential.

This study aims to address this research problem by exploring how human-centric principles can be integrated into the digital transformation efforts within the construction industry. It will specifically examine change management theories and models that can facilitate this integration. Change management theory focuses on the processes and methodologies that enable organisations to transition from their current state to a desired future state, factoring in both technological advancements and the impact on individuals and

teams (Iskandar *et al*., 2020). However, traditional change management models may not fully account for the rapid technological changes, the need for continuous digital upskilling, or the unique challenges posed by the construction industry's established processes (Robertson and De Vellis, 2023).

This study seeks to fill the gap by proposing a tailored change management framework designed to align human-centric principles with digital transformation strategies in construction. By conducting a systematic literature review, this paper will identify relevant change management models and human-centric principles applicable to construction organisations. The findings will inform the development of a specialised change management framework that supports both technological advancement and human-centred organisational practices.

This paper is structured as follows: Section 2 outlines the methodology used for the systematic literature review. Section 3 presents the key findings from the literature review, focusing on human-centric principles and change management activities relevant to the construction industry. Section 4 offers recommendations for developing an effective change management framework, and the Conclusions section summarises the key implications of this research and suggests future directions.

2. Research design and methods

This study adopts a pragmatic research philosophy, which allows for the integration of multiple perspectives and methodologies to address practical research problems (Melnikovas, 2018). Pragmatism is particularly suitable for this research as it enables the combination of systematic literature analysis with quantitative network analysis techniques to develop practical solutions for industry challenges.

Building upon comparable quantitative analyses in construction research (Jafari *et al*., 2020; Wang *et al*., 2020; Liu *et al*., 2024), this study employed a multi-phased research design, utilising both systematic literature reviews (SLRs) and advanced network analysis techniques to develop a change management framework tailored for the construction industry with a focus on human-centric principles. The research methodology was carefully structured to identify and analyse change management activities and principles that prioritise human needs, while also quantifying their relationships and significance within the broader network of industry practices. This design ensures that the methodology aligns with the research objectives by integrating both qualitative and quantitative methods. The high-level research process is outlined in Figures 1 and 2 illustrates the research design flowchart.

2.1 Systematic literature review

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and applied content analysis to gather the necessary data aligned with the research objectives. PRISMA provides a standardised framework with a checklist, carefully followed here to uphold quality assurance and enhance the reproducibility of the review process.

2.1.1 Search procedure. Two systematic searches were carried out on Scopus, to ensure comprehensive coverage while maintaining search precision and relevance. This dual-search approach was necessitated by the distinct nature of the two core research components: human-centric principles and change management activities.

Keywordsand synonyms relevant to each topic were combined to form the search term, as outlined in Table 1, and searches targeted the article titles, abstracts, and keywords.

2.1.2 Eligibility criteria and screening process. To assess the quality of the selected articles, specific inclusion and exclusion criteria were applied to ensure both relevance to the research objectives and methodological rigour, as detailed in Table 2.

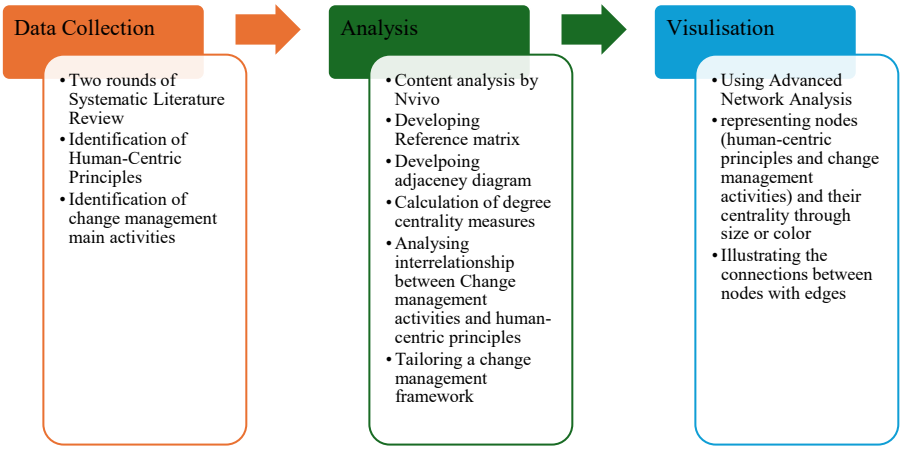

Figure 1. Overview of the research process. Source: Authors' own work

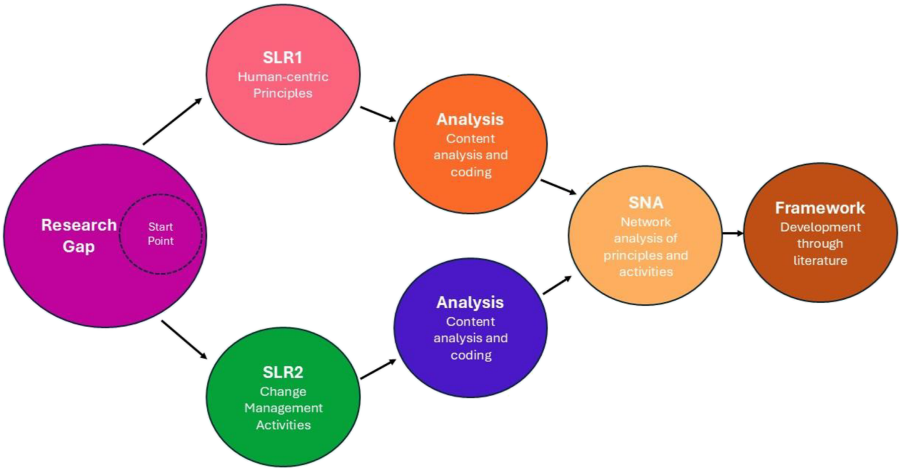

Figure 2. Research design flowchart. Source: Authors' own work

Table 1. Search query

Search databases	Search term
Scopus (SLR1)	("Human centric" OR "Human element" OR "people centric" OR "People oriented" OR "People focused") AND ("Digital transformation" OR "Digital" OR "Technology") AND ("Construction")
Scopus (SLR2)	("change management" OR "change model" OR "change theory" OR "organisational change") AND ("Digital transformation" OR "Digital" OR "Technology") AND ("Construction")

Source(s): Authors' own work

Table 2. Employed eligibility criteria

Inclusion criteria	Exclusion criteria
Written in English	Papers in languages other than English
Peer-reviewed publications	Not peer-reviewed scientific reports and documents
Relevant to the aims of this study	Outside the scope of this research
Within the scope of the construction industry	Not applicable to the construction industry

Source(s): Authors' own work

A multi-step process was also used to screen and review the papers that were initially identified. In the first stage, Scopus filters, such as document type, subject area, and source title, were applied to narrow down the articles and exclude those that did not meet the eligibility criteria. This was followed by removing duplicates, screening titles and abstracts, and applying inclusion and exclusion criteria during the full-text review. To capture essential publications, backward and forward citation searches were also conducted.

2.2 Social network analysis

Social Network Analysis (SNA) is a research method that examines relationships between different elements by treating them as a network of connected points (similar to mapping connections in a social group), particularly degree centrality, quantify each element's importance by measuring its connections to other elements. SNA leverages graph theory to examine how variables within a network are interconnected, enabling insights into network behaviour (Elsayegh and El-adaway, 2021). SNA was selected over alternative methods such as correlation analysis or factor analysis because it captures relational patterns between elements rather than treating them as independent variables, which is essential for understanding how change management activities and human-centric principles function as an integrated system. Unlike qualitative content analysis alone, SNA provides quantitative centrality measures to objectively identify the most influential elements within the network.

SNA represents these connections through nodes and edges, using various metrics for detailed analysis. Among these, centrality measures, especially degree centrality (DC), are widely regarded as effective for determining a node's significance in a network (Hosseini *et al.*, 2018). This study applies DC to quantify the importance of each node, with SNA chosen for its capability to assess interactions between human-centric principles and change management activities. Additionally, SNA offers valuable visualisations that reveal underlying connections and patterns often missed in simpler analyses (Sheikhkhoshkar *et al.*, 2023).

3. Results and analysis

The systematic search and screening process identified 64 sources (journals, conference papers, and reports), which formed the foundation for the study's analysis. From this comprehensive review, the study identified 10 change management models, which served as the basis for extracting 20 change management main activities and numerous human-centric principles. These findings will be elaborated upon in subsequent sections.

3.1 Systematic literature review

To begin with, this study commenced with the implementation of two systematic literature reviews (SLRs). The primary SLR focused on examining various change management models, with the aim of extracting the fundamental activities associated with them. The secondary SLR delved into exploring human-centric principles, specifically within the construction industry. Both SLRs strictly adhered to the PRISMA guidelines in Figures 3 and 4, ensuring a structured and transparent process throughout. For SLR1 (Human-Centric

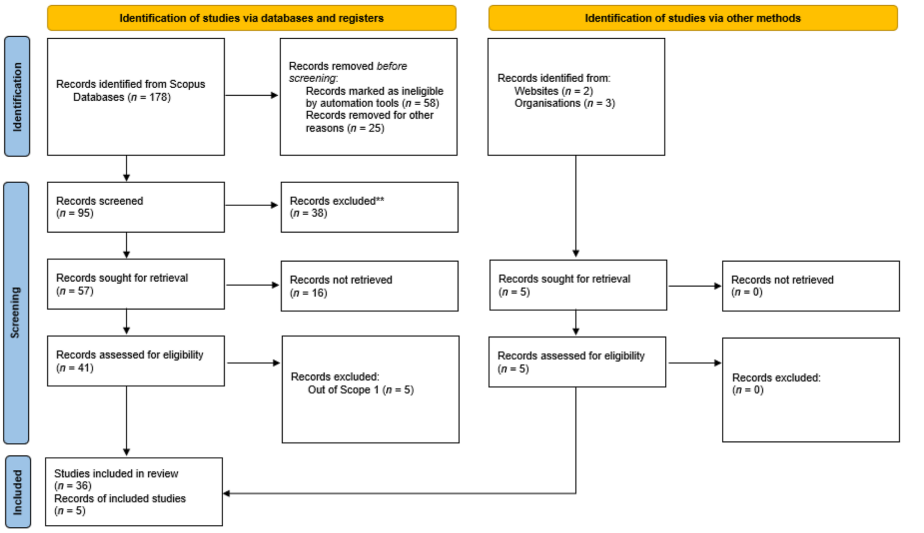

Figure 3. The first round of literature review (Human-Centric Principles) using PRISMA guidelines. Source: Authors' own work

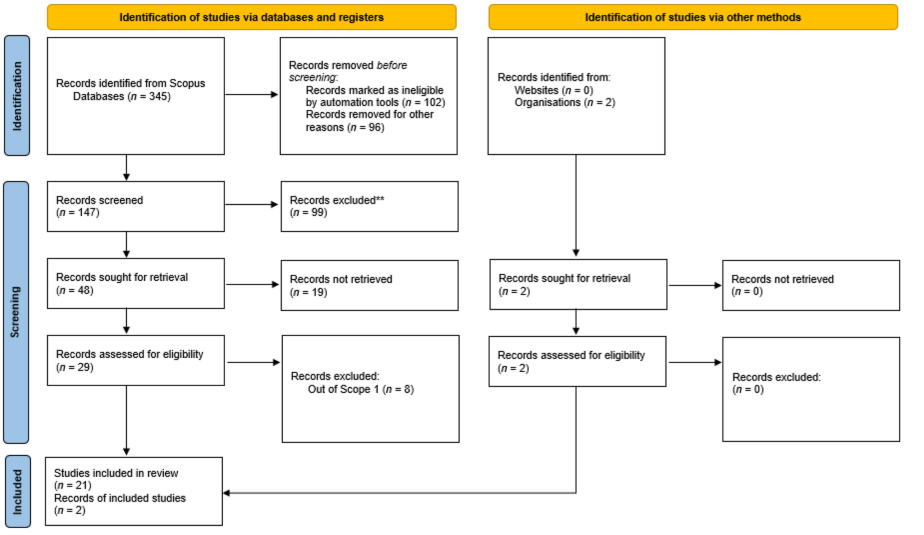

Figure 4. The second round of literature review (Change Management activities) using PRISMA guidelines. Source: Authors' own work

Principles), the initial Scopus search yielded 178 records. After applying document type and language filters, 120 records remained. Following duplicate removal, 95 records underwent title and abstract screening, with 54 records excluded due to insufficient relevance to human-centric principles in construction, technology focus without human considerations, and lack of theoretical foundation. This resulted in 41 records for full-text assessment, with 5 additional exclusions during full-text review, yielding 36 papers plus 5 organisational reports, ultimately 41 studies.

For SLR2 (Change Management Activities), the initial search identified 345 records, reduced to 102 after filters, and 96 after duplicate removal. Title and abstract screening excluded 118 records primarily due to a lack of specific change management activities, resulting in 29 records for full-text review. Eight records were excluded during full-text assessment, yielding 21 papers plus 2 organisational reports, ultimately 23studies.

This rigorous approach resulted in the compilation of a comprehensive list of change management activities and human-centric principles, which were subsequently refined through content analysis utilising NVivo software.

3.2 Content analysis and coding

After the screening phase, a content analysis was conducted on 41 papers to identify human-centric principles and 23 papers to identify change management's main activities. The finalised papers were systematically coded to extract human-centric principles through automated content analysis, identifying themes based on frequency and conceptual clustering (detailed procedures in Appendix A.1).

Furthermore, a deep dive into ten change management models extracted from the 23 papers resulted in the identification of 20 change management activities considered essential and beneficial for the purpose of this study (detailed in Table 3). Additionally, a total of 3,813 human-centric principles were extracted from the 41 approved papers. To streamline the analysis, the authors aggregated principles with similar concepts and removed irrelevant and duplicated principles, ultimately resulting in a refined set of 419 human-centric principles under the 18 categorised principles for further analysis (comprehensively presented in Table 4 with representative subcategories and mention frequencies).

3.3 Overview of change management models

Table 5 presents the 10 change management models identified through the literature review, which could play a crucial role in shaping the construction industry's digital transformation strategies. These models provided the foundation for identifying the main activities in change management.

3.4 Change management activities

The 20 change management activities are derived from the 10 change management models listed in Table 5. These activities were identified through a rigorous content analysis using NVivo software, as described in the research design section. Activities were classified as "critical" if they appeared in more than one model, reflecting a broad consensus on their importance in effective change management practices.

This systematic approach ensures that the activities presented have been consistently recognised across different change management frameworks. Table 3 provides a detailed breakdown of these activities, which form the foundation for implementing effective change management strategies in human-centric digital transformation efforts.

3.5 Human-centric principles

The systematic analysis yielded 419 human-centric principles, consolidated into 18 categories. Only principles mentioned in at least 3 sources were considered for analysis. The final categorisation into 18 groups was based on both automated clustering and manual review by the researchers, allowing for a more detailed examination of how these principles interact with the identified change management activities.

3.6 Social network analysis (SNA)

Social Network Analysis (SNA) was employed to quantitatively assess the relationships between identified change management activities and human-centric principles. The analysis

Table 3. Highlighted change management activities

ID	Change management activity	Reference
CHA_1	Defining a clear vision and strategy	Mento *et al*. (2002), Chuang and Yang (2023)
CHA_2	Alignment with mission and strategy	Raineri (2011), İkinci (2014), Sung and Kim (2021)
CHA_3	Creating a sense of necessity	Bugubayeva *et al*. (2017), Lugonja (2020), Pacolli (2022)
CHA_4	Assessing organisational competencies	Al-Haddad and Kotnour (2015), Pacolli (2022)
CHA_5	Considering individual skills and abilities	Bellantuono *et al.* (2021)
CHA_6	Allocating sufficient resources	Alban (1987), Ali *et al.* (2021)
CHA_7	Establish a skilled and experienced change team	Bullock and Batten (1985), Beckhard (1987), Smith *et al.* (2014)
CHA_8	Constant communication with all stakeholders during change	Galli (2018)
CHA_9	Monitoring and evaluating communication effectiveness	Bullock and Batten (1985), Beckhard (1987), Smith *et al.* (2014)
CHA_10	Motivating the change agents	Kickert (2014), Galli (2018)
CHA_11	Creating quick wins	Anthony Mento and Dirndorfer (2002), Brisson-Banks (2010)
CHA_12	Engaging stakeholders	Ramiah and Moore (2023), Wernicke *et al.* (2023)
CHA_13	Training	Al-ohali *et al.* (n.d.), Wernicke *et al*. (2023)
CHA_14	Identifying and managing resistance to change	Joseph (2020), Lugonja (2020), Ramiah and Moore (2023)
CHA_15	Establish and empower change leadership	Burnes (2004), Kickert (2014), Frost *et al.* (2020), Lugonja (2020), Carnicero *et al.* (2021), Petersson *et al.* (2022), Shaharruddin and Musa (2022)
CHA_16	Continuous improvement	Jonas (202), Kabashkin *et al.* (2023)
CHA_17	Developing a change plan	Burnes (2004)
CHA_18	Progress monitoring	Bullock and Batten (1985), Wincek *et al.* (2013), Bugubayeva *et al.* (2017)
CHA_19	Integrating lessons learned	Brisson-Banks (2010), Bugubayeva *et al.* (2017)
CHA_20	Developing reinforcement strategy and creating cultural fit	Frost *et al.* (2020), Etareri *et al.* (2022)

Source(s): Authors' own work

was conducted by constructing a bipartite network graph *"$G = (V, E)$"*, where *V* represents the set of vertices (nodes) and *"E"* the set of edges (connections). Nodes were defined as *"$V = A \cup P$"*, with *"A"* representing the set of activities and *"P"* the set of principles, ensuring no overlap (*"$A \cap P = \varnothing$"*). Edges were determined based on the co-occurrence matrix C, derived from the literature, where *"$C\_ij = 1$"* if activity *"i"* is connected to principle *"j"*, and *"0"* otherwise. The graph was then analysed using the NetworkX library in Python to explore the network structure and quantify the interconnectedness of the nodes.

In the systematic mapping of change management activities to human-centred principles, the research methodology adopted a scientifically rigorous approach, ensuring that all relationships were derived from a replicable process, free from subjective bias. The stages involved were as follows:

Table 4. Identified human-centric principles

ID	Category	Number of codes	Representative subcategories	Number of mentions
HCP_1	Human Capabilities	53	Human experience	10
			Human values	6
			Human intelligence	4
HCP_2	Individual Requirements	25	Individual assessments	4
			Individual creativity	4
			Individual needs	3
HCP_3	Work Environment	46	changed work practices	12
			social work practice	7
			future works	4
HCP_4	System Thinking	38	Cyber-physical systems	10
			Entire system	6
			integrated system	5
HCP_5	Process	24	Organisation processes	4
			Process management	3
			Process optimisation	3
HCP_6	Organisational Essentials	17	Human-centred organisations	5
			Learning organisation	4
			Innovative organisation	3
HCP_7	Business Requirement	19	Business value creation	4
			Business case	4
			Business ethics	3
HCP_8	Interactions	16	Employee interactions	4
			Human-system interaction	3
			Interaction designs	2
HCP_9	Environment	7	Learning environments	3
			Changing environment conditions	3
			Supportive environment	3
HCP_10	Management Skills	29	Change management	5
			Project management	5
			Human resource management	4
HCP_11	Tasks Separation	28	Dynamic task planning	3
			Task management	3
			Collaborative tasks	3
HCP_12	Design Requirements	17	Process design	10
			Innovation design approach	4
			Human-centred design	4
HCP_13	Leadership approach	17	Human-centred approach	12
			Innovative approaches	5
			Six sigma approach	3
HCP_14	Development Path	14	sustainable development	8
			Employee development	7
			strategy development	5
HCP_15	Change Management Strategy	16	Organisational change	13
			Sustainable changes	5
			Innovative change	3
HCP_16	Knowledge Management	25	Knowledge management	5
			Knowledge sharing	3
			Organisational knowledge	3
HCP_17	Value	13	Human values	6
			Value maximisation	4
			Shared values	3
HCP_18	Technology Requirements	15	artificial intelligence technology	3
			knowledge management technologies	3
			Communications technologies	3

Source(s): Authors' own work

Table 5. Change management models

Row	Change management model	Reference
1	Kotter's 8-Step Change Model	Kotter (1995)
2	Lewin's Three-step Change Model	Juneja (2020)
3	ADKAR	Ali *et al.* (2021)
4	McKinsey's 7-S	Etareri (2022)
5	Bridges' Model of Transition	Miller (2017)
6	Bullock and Batten's Change Model	Bullock and Batten (1985)
7	Mento *et al.*'s Change Model	Mento *et al*. (2002)
8	Kickert	Kickert (2014)
9	Change Formula of Beckhard and Harris	Beckhard (1987)
10	Change Management Body Of Knowledge	Smith *et al.* (2014)

Source(s): Authors' own work

(1) Automated Text Analysis: The initial extraction of human-centred principles was facilitated by the application of NVivo software, which utilised advanced natural language processing algorithms to systematically identify recurring themes from the literature. This approach ensured an unbiased, data-driven foundation for the mapping.

(2) Co-occurrence Matrix Generation: The extracted themes were then used to construct a co-occurrence matrix. In this matrix, binary indicators (1 or 0) denoted the presence or absence of a relationship between each pair of change management activity and human-centred principle, based on their concurrent mention within the themes of the literature reviewed.

(3) Conceptual Validity: The contextual application of each principle and activity was examined, ensuring that their pairing was conceptually valid and substantiated by evidence in the literature.

3.7 Quantitative analysis

Centrality measures were calculated to identify the prominence of each node within the network, essentially determining which elements are most connected and influential (Jafari *et al.*, 2020; Liu *et al.*, 2024). The degree centrality for a node "*v*", representing its connectedness, was computed using the formula:

$$CD(v) = \frac{deg(v)}{n-1}$$

Where "deg(v)" is the degree of node "v" (i.e. the number of direct connections) and "*n*-1" is the maximum possible degree in the network (i.e. the total number of other nodes it could potentially connect to). Centrality measures were normalised to enable standardised comparison across all network nodes, identifying the relative importance of each change management activity and human-centric principle (calculation details in Appendix A.3).

3.8 Validation through visual analytics

To visually validate and interpret the network structure, we employed comprehensive visual analytics techniques following established methodologies in bibliometric studies (Elsayegh and El-adaway, 2021; Sheikhkhoshkar *et al.*, 2023). Network visualisation was generated with node sizes proportional to their centrality values, enabling intuitive identification of the most

influential elements (Figure 5). Visual encoding used colour intensity to represent centrality levels, with darker nodes indicating higher influence within the network (Visual encoding parameters are detailed in Appendix A.4). The scripts developed facilitated an advanced analysis, which forms the foundation for our proposed change management model, emphasising its adaptability and human-centric focus within the evolving landscape of the construction industry.

3.9 Mapping of change management activities to human-centric principles

To explore the relationships between change management activities and human-centric principles, a reference matrix V was developed. This matrix has dimensions of 18 by 20, representing the 18 categories of human-centric principles and 20 change management activities identified in two SLR processes.

Each element of the matrix, V (i, j)e.

(1) 1 indicates a relationship between activity i and principle category j, meaning they co-occur in the reviewed literature and

(2) 0 indicates no relationship.

The data from Matrix V is presented in Figure 5, showing how specific change management activities align with human-centric principles. The figure reflects the binary values from Matrix V, where 1 indicates a relationship and 0 indicates no relationship.

Figure 5 presents the binary mapping matrix where dark cells (value = 1) indicate established relationships between change management activities (rows) and human-centric

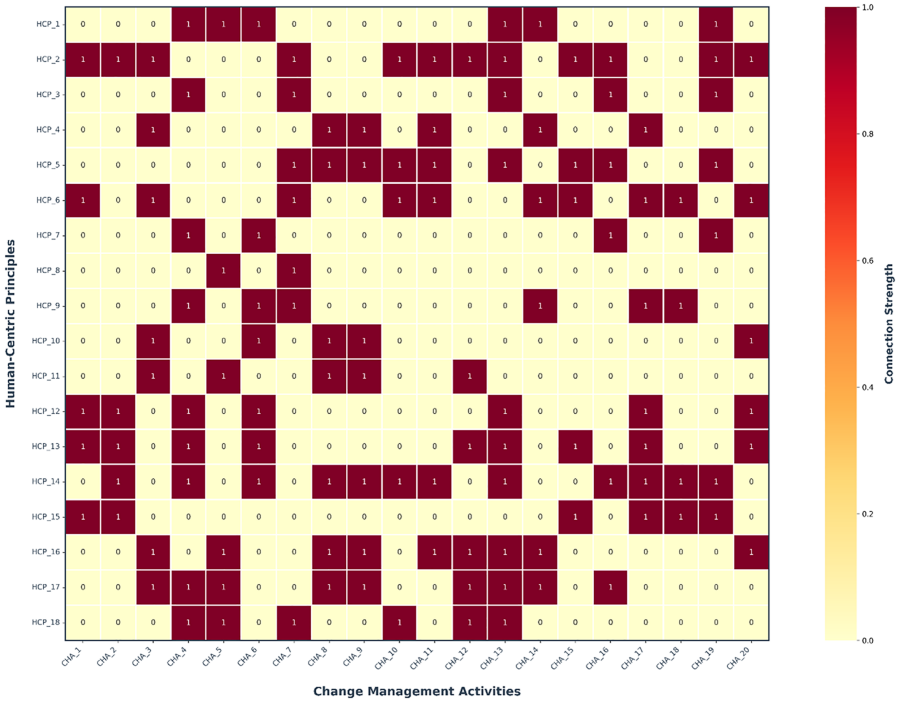

Figure 5. Mapping of change management's main activities and the human-centric principles. Source: Authors' own work

principles (columns), while white cells (value = 0) indicate no documented relationship in the literature. This mapping serves as the basis for the subsequent network analysis, where these relationships are explored in more detail.

3.10 Adjacency matrix of human-centric principles

An adjacency matrix was generated from the reference matrix. The values within this matrix represent the weight of connections between nodes, with cells colour-coded to reflect the strength of these connections, as depicted in Figure 6. Figure 6 displays the adjacency matrix where colour intensity represents connection strength between human-centric principles. White cells indicate no co-occurrence (weight = 0), light orange indicates moderate connections (weight = 1–2), and dark orange indicates strong interconnections (weight = 3+). The strong connection between HCP_14 (Development Path) and HCP_2 (Individual Requirements), shown in dark orange, suggests these principles frequently co-occur in change management contexts, indicating their complementary nature in organisational transformation.

While the adjacency matrix in Figure 6 illustrates the complex interconnections between human-centric principles, it does not directly indicate which elements are most critical for driving digital transformation in change management. To gain deeper insights, a centrality analysis was performed in the following section to identify the most influential nodes within the network.

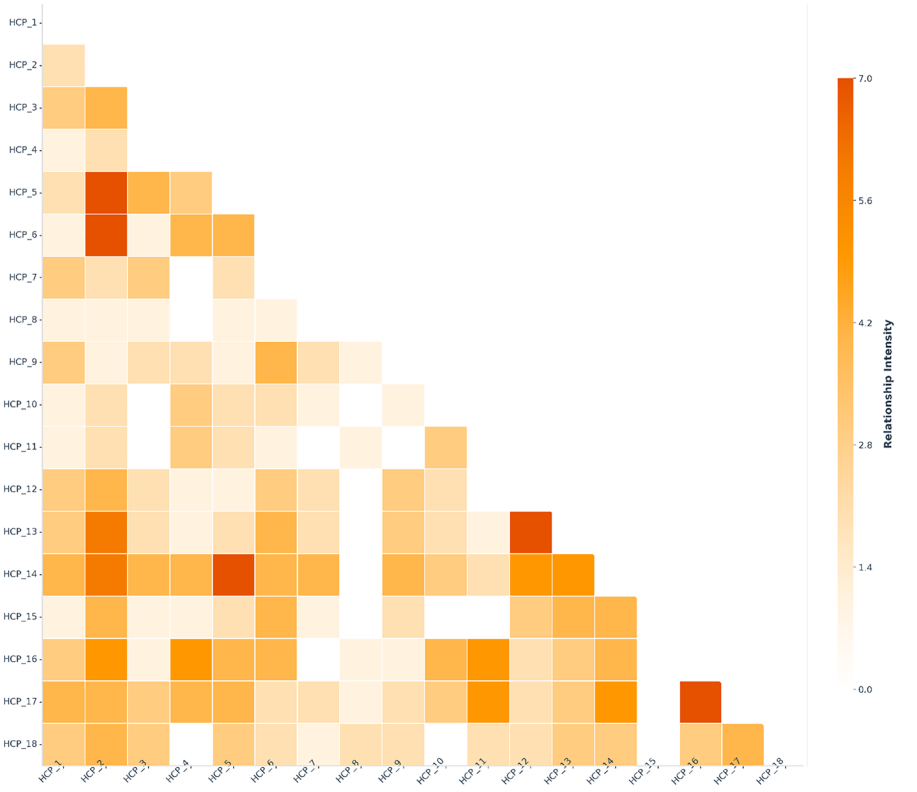

Figure 6. Adjacency matrix of human-centric principles. Source: Authors' own work

3.11 Centrality analysis

To further explore the relative importance of each node in the network, a centrality analysis was performed. Centrality measures quantify the influence of each change management activity and human-centric principle within the network by identifying the most connected and influential nodes. This analysis helps determine which elements play a pivotal role in facilitating digital transformation.

The degree centrality of each node was calculated and normalised, allowing for comparison across the network. Figure 7 presents the results of the centrality analysis, where:

(1) Darker nodes represent change management activities and categories of human-centric principles with higher centrality values, indicating stronger influence and higher interconnectedness within the network.

(2) Lighter nodes represent activities and categories of principles with lower centrality values, indicating a relatively weaker influence on the network structure.

For example, CHA_13 (Training) and HCP_14 (Development Path) were found to be highly influential, connecting multiple activities and principles. These elements, due to their higher centrality, are likely to play a critical role in driving effective change management in the context of digital transformation.

4. Discussion

The network analysis conducted in this study uncovers a detailed and intricate map of the connections between change management activities and human-centred principles in the

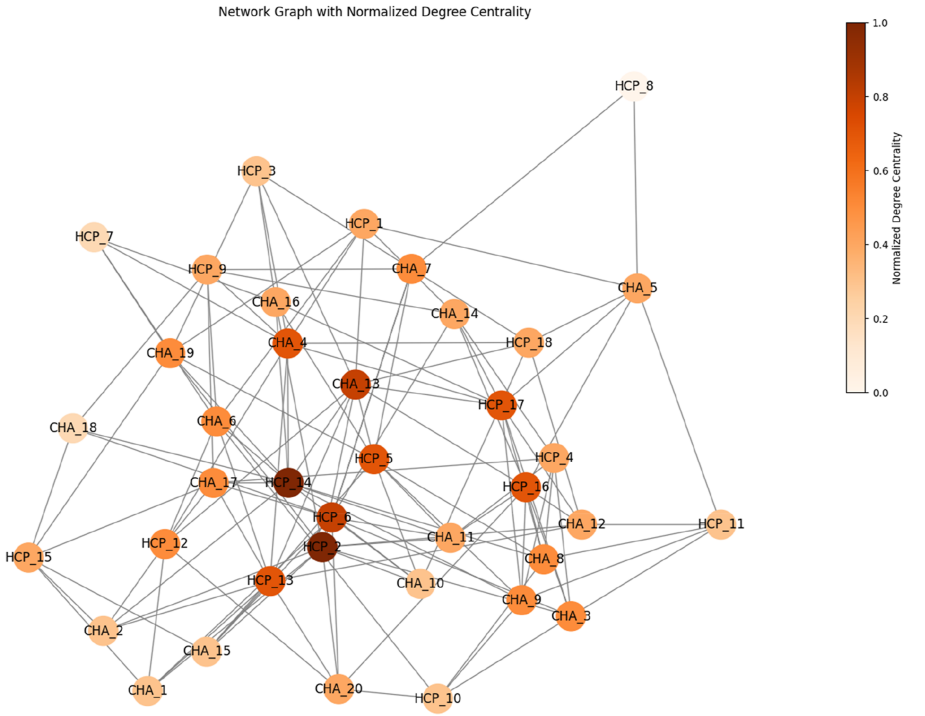

Figure 7. Normalised degree of centrality for change management activities and categories of human-centric principles. Source: Authors' own work

context of digital transformation within the construction industry. By conducting two rounds of systematic literature review, we carefully identified and mapped a network of interconnected change management activities and human-centred principles. The resulting binary matrix and network visualisation, which were generated using rigorous scientific methods instead of subjective opinions, offer solid empirical evidence supporting the resulting binary relationship matrix.

The visual analytics and normalised centrality calculations, conducted using Python and supported by Social Network Analysis (SNA), revealed the crucial role of these activities and principles in effective change management. The strategic emphasis on high-centrality nodes suggests a new paradigm in managing organisational change. This finding aligns with recent works, that similarly identified the importance of integrating technological advancement with human factors in construction automation (Turek *et al*., 2017; Jafari *et al.*, 2020; Singh *et al*., 2022; Zhang *et al.*, 2023; Bidhendi and Poshdar, 2024). Our network analysis extends their findings by quantifying these relationships through advanced metrics.

The discussions in this study focus on the importance of specific nodes within the network. Activities such as training (CHA_13), assessing organisational competencies (CHA_4), developing a change plan (CHA_17), allocating sufficient resources (CHA_6), and human-centred principles such as individual requirements (HCP_2), development path (HCP_14), organisational essentials (HCP_6), and process (HCP_5) are among the most interconnected nodes within the network. These nodes have consistently shown to be focal points in the literature, suggesting their fundamental role in catalysing effective change within organisations. This finding supports recent research by Davila Delgado *et al*. (2019), who emphasised the importance of organisational readiness and awareness in successful construction robotics implementation. The centrality of these elements reinforces their significance in our tailored change management framework, underscoring the need for organisations to ignite a shared urgency for change and to fully harness the potential of their human capital.

Conversely, principles such as value (HCP_17), interactions (HCP_8), tasks separation (HCP_11), management skills (HCP_10), human capabilities (HCP_1), and technology requirements (HCP_18), which demonstrate moderate to low centrality, signify areas where change management activities may need to be developed or emphasised. These principles are crucial for a holistic human-centred approach yet may be underrepresented in current change management strategies. This finding aligns with work by Wang *et al*. (2025), who identified similar gaps in technology adoption readiness. By incorporating activities that directly support these principles, such as reinforcing shared values or aligning technology with human needs, organisations can aspire to a more comprehensive and inclusive change management approach.

The customised change management framework (Figure 8) hinges on two key pillars: focusing on the most central activities and principles and fostering the less-connected yet vital human-centred principles. This dual strategy aims to ensure that both high-impact activities and underrepresented but critical principles are effectively incorporated into organisational change strategies.

The framework provides a structured approach to implementing digital transformation while keeping people at the centre of change. It is organised into three sequential phases, Strategic Initialisation Phase, Operational Transformation Phase and Sustainable Integration Phase, each building upon the previous one to ensure comprehensive and sustainable transformation.

The framework includes the following components:

(1) *Strategic vision and communication:* Clear articulation of the change vision is essential. Aligning technological advancements with organisational values and human-centred principles ensures stakeholder buy-in, reducing resistance and promoting collaboration throughout the organisation.

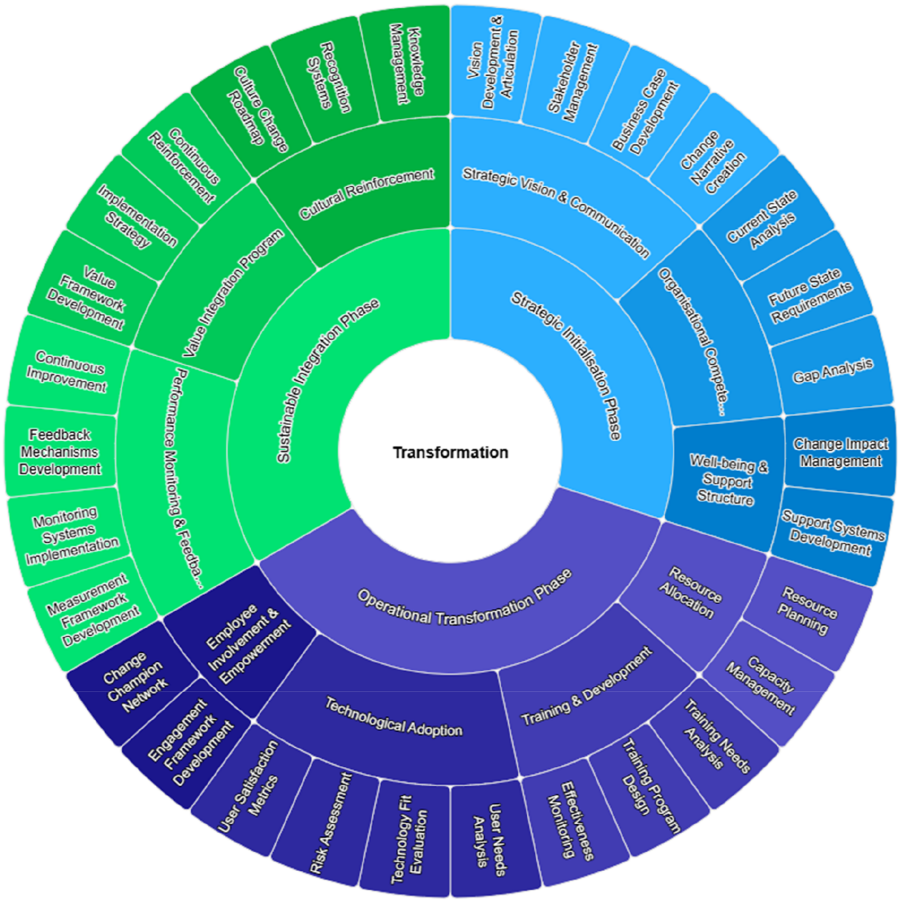

Figure 8. Human-centric digital transformation customised organisational change management framework. Source: Authors' own work

(2) *Organisational Competencies Assessment:* A comprehensive assessment of the existing skills, capabilities, and resources within the organisation is critical to ensuring they align with strategic digital transformation goals. This includes identifying areas of strength and recognising where further development is required. A continuous improvement process must be embedded in the organisation's culture, with regular competency reviews and updates to ensure alignment with evolving technological and market demands

(3) *Well-being and support structures:* Recognising the stress associated with change, the framework incorporates support structures to maintain employee well-being and productivity during transitions.

(4) *Resource allocation:* Ensuring that sufficient resources, both financial and human, are allocated effectively to support change initiatives is crucial. This guarantees that logistical constraints do not impede the change process, and that the necessary infrastructure is in place for success.

(5) *Comprehensive training and development:* Given the central role of training (CHA_13) in the network analysis results, equipping employees with the skills required for the digital era. Beyond technical training, personal development in adaptability, problem-solving capabilities, and emotional intelligence ensures that employees are both capable and willing to embrace change.

(6) *Technological adoption:* The selection and implementation of technologies must prioritise human empowerment. Technologies should augment rather than replace human capabilities, and their selection should involve a participatory approach, ensuring that employee needs are met and work processes are improved.

(7) *Employee involvement and empowerment:* Fostering an inclusive atmosphere where employees feel valued and actively involved in the change processes helps mitigate the risk of disengagement, which often results from top-down approaches. Integrating employee participation strengthens the innovative potential of the workforce.

(8) *Performance monitoring and feedback:* Establishing mechanisms for feedback and performance tracking ensures continuous improvement. Real-time data should inform adjustments to change strategies, enhancing the likelihood of success.

(9) *Value integration programs*: Embedding shared human-centric values into organisational operations ensures that these values are upheld across all business processes. This fostered a work environment where employees feel valued, leading to enhanced employee loyalty and improved corporate reputation.

(10) *Cultural reinforcement:* Embedding changes within the organisational culture is essential for their sustainability. Recognising successes and contributions reinforces desired behaviours and helps solidify the new practices.

This framework is not static; it is adaptable and designed to evolve as new insights emerge from theoretical advances and practical applications. Recent studies have demonstrated that successful digital transformation frameworks must balance standardisation with flexibility (Li *et al.*, 2022; Zhang *et al.*, 2023). The framework also demonstrates scalability through its modular implementation structure. Organisations can implement components progressively based on their readiness and resources. The framework's modular design enables adaptation across different project sizes (small firms focusing on high-centrality elements first), cultural contexts (principle-based implementation allowing local variations), and technological maturity levels (multiple entry points for organisations at different digital development stages).

The framework's validity is established through its systematic development methodology and evidence-based foundation. All components represent change management activities and human-centric principles already validated in the reviewed literature, ensuring practical applicability. The network analysis provides novel prioritisation of these proven practices rather than introducing untested concepts. Future research phases will include empirical validation through organisational case studies to test implementation effectiveness.

4.1 Strategic implications of network centrality for change management practice

The centrality analysis reveals practical guidance for construction organizations implementing digital transformation. High-centrality nodes represent multiplicative investment opportunities where focused attention yields disproportionate returns across the entire change management system. Training (CHA_13), with its high centrality, should receive priority resource allocation because it simultaneously supports multiple human-centric principles, including Human Capabilities (HCP_1), Knowledge Management (HCP_16), and Work Environment (HCP_3).

Organisations should interpret centrality measures as risk and opportunity indicators; failure to adequately address high-centrality elements creates systemic vulnerabilities that can undermine the entire transformation effort, while success in these areas creates positive momentum that facilitates implementation of other framework components. This network-based prioritisation approach enables organisations to achieve maximum transformation impact with optimal resource utilisation.

Construction organisations can operationalise this framework through several concrete steps: (1) Establish dedicated training programs as the primary investment focus, given Training's (CHA_13) high centrality and multiplicative effects; (2) Create clear development pathways for employees, aligning with Development Path's (HCP_14) central role in supporting multiple human-centric principles; (3) Conduct comprehensive organisational competency assessments (CHA_4) before digital technology implementation to identify capability gaps; and (4)Allocate proportionally higher resources to high-centrality activities while maintaining coverage of supporting elements.

For construction managers, this means prioritising workforce development before technology deployment to reduce project disruption risks. Contractors can use this prioritisation to allocate limited budgets more effectively, investing in training programs that enable multiple subsequent digital initiatives rather than scattered technology purchases. Policy-makers can target industry support programs at these high-centrality elements to achieve maximum industry-wide digital transformation impact.

Organisations should adopt a phased approach, beginning with high-centrality elements in Phase 1 (Strategic Initialisation), integrating medium-centrality elements in Phase 2 (Operational Transformation), and consolidating all components in Phase 3 (Sustainable Integration) as outlined in the proposed framework.

While this study provides the foundational prioritisation framework, future research will investigate specific implementation challenges, develop detailed implementation strategies, and examine contextual factors that may influence framework adaptation across different organisational sizes and project types. Subsequent studies will also identify potential barriers to high-centrality element implementation and provide evidence-based solutions for overcoming these challenges in construction industry contexts.

4.2 Study limitations and generalisability

This study acknowledges several limitations. First, reliance on secondary data from published literature means the framework is constrained by the scope and quality of existing research.

Second, the network analysis reflects relationships as identified in the literature rather than empirically validated connections in real organisational contexts. While this approach ensures comprehensive theoretical grounding, future studies should validate these relationships through direct organisational observation.

Regarding generalisability, the framework was developed specifically for the construction industry's unique characteristics, including project-based work structures, multi-stakeholder environments, and complex technology integration requirements. While core change management principles may be applicable across industries, the specific prioritisation and human-centric focus reflect construction industry contexts. Future research should examine the framework's adaptability to other industries with different organisational structures and digital transformation requirements.

5. Conclusion

This research addresses a significant gap in the journey beyond BIM by recognising that successful digital transformation in construction depends not just on technological solutions but on human-centred change management. While BIM and other digital technologies offer tremendous potential for improving efficiency and collaboration in construction, their

adoption has been hindered by insufficient attention to the human dimensions of change. The framework developed in this study provides a structured approach for organisations seeking to move beyond current BIM implementation barriers by integrating human-centric principles with technological advancement. By emphasising the framework's elements, it offers a pathway to address the human factors that have limited the transformative impact of BIM in the AECO industry.

Findings from two systematic literature reviews and advanced network analysis reveal significant interconnectedness between change management activities and human-centric principles. These insights informed the development of a comprehensive change management framework that prioritises strategic vision and communication, robust training programs, efficient resource allocation, and enhanced employee involvement and empowerment. The framework also includes a performance monitoring system and feedback mechanisms, as well as well-designed support systems to ensure employee well-being, thereby ensuring that technological changes do not overshadow human factors.

The proposed framework is distinct because it emphasises the most influential change management activities and human-centred principles while addressing the less prominent yet crucial factors, thereby providing a well-rounded approach. This balance is key to increasing the adaptability and resilience of construction organisations, empowering them to manage digital transformation effectively.

The theoretical contributions of this study lie in its focus on integrating human-centric values into digital change management, an area previously underexplored in the construction sector. In practical terms, the framework offers actionable insights for industry professionals. Furthermore, the model's inherent flexibility suggests potential applicability beyond the construction industry, offering value to sectors facing similar transformational challenges. This broader applicability highlights the framework's relevance and utility in a variety of organisational contexts.

In conclusion, this research marks a significant step in reshaping change management practices in the digital era, specifically within construction management. It provides construction managers, contractors, and policymakers with evidence-based guidance for digital transformation that addresses documented industry barriers. The framework's prioritization approach enables more effective resource allocation and risk reduction in technology implementation, directly supporting industry-wide digitalization efforts. The proposed framework effectively blends technology-driven change with human-centric values, promoting organisational success and employee satisfaction. Future research directions include: (1) empirical validation through case studies with construction organisations of varying sizes, (2) integration strategies with existing project management and BIM systems, (3) development of implementation tools and assessment metrics, (4) adaptation and testing in related project-based industries such as engineering consultancy and infrastructure development, and (5) investigation of cultural and regional factors affecting framework implementation. Continued empirical validation and iterative refinement through both industry application and scholarly review will enhance its robustness and practical applicability.

Appendix
Technical implementation details

A.1 NVivo content analysis procedure

The content analysis was conducted using NVivo Qualitative Data Analysis software (Version 12), specifically utilising its auto code feature to extract human-centric principles. NVivo employs a language pack to analyse materials, identifying themes by analysing content and sentence structure. The software assigns significance to themes based on their frequency within the analysed material. These themes are then grouped, and results are presented as nodes representing broad ideas, with child nodes representing individual themes within each group.

A.2 Python implementation for network analysis

The network analysis was implemented using Python 3.8 with the following libraries:

(1) NetworkX (version 2.6) for graph-based calculations and centrality measures

(2) pandas (version 1.3.0) for data manipulation and matrix operations

(3) matplotlib (version 3.4.2) for network visualization

A.3 Centrality calculation details

Normalised degree centrality C'D(v) for a node "v" was obtained using the formula:

$$CD'(v) = CD(v)/\max\_\{u \in V\} CD(u)$$

Where max_{u ∈ V} CD(u) is the maximum degree centrality observed in the network.

A.4 Visualisation parameters

Visual encoding was defined by the mapping: colour(v) = ColourMap(CD'(v)), where ColourMap is a function that maps the normalized centrality measure to a colour gradient. Node sizes were set proportional to centrality values using the formula: size(v) = base_size × (1 + scaling_factor × CD'(v)).

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