Fostering Digital Transformation through Project Integration Management

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Abstract

Digital transformation has presented significant challenges across industries, with the construction sector notably appearing to lag in adoption and implementation. Whilst the proliferation of digital technologies may have catalysed incremental improvements in construction project execution, the full transformative potential appears to remain unrealised, largely due to organisational impediments. This apparent disparity between technological capabilities and organisational readiness suggests the need for a paradigmatic shift in project management approaches within construction enterprises. Extant literature has largely focused on the technical dimensions of digital transformation in construction, with relatively limited scholarly attention directed towards the organisational dynamics and project management paradigms that underpin successful digital integration. This research aims to address this potential gap in the literature by examining how project integration management can facilitate digital transformation in construction projects through a qualitative case study approach. Drawing upon a comprehensive literature review, the study seeks to develop an integrated framework for construction project management. The empirical investigation centres on a representative project in mainland China, employing systematic data analysis to synthesise a novel project integration management model oriented towards digital transformation. This model facilitates organisational adaptation to technological innovation whilst providing construction enterprises with a methodological framework to develop their digital transformation initiatives. The findings contribute to both theoretical understanding and practical implementation of digital transformation strategies in the construction industry.

Keywords: Digital Transformation, Digitalisation, Construction Projects, Project Integration Management.

1. Introduction

In today's era of rapid technological advancement, new innovations are fundamentally reshaping human behaviours and transforming work processes. In this context, embracing digital technologies is no longer optional but essential for industries and enterprises striving to maintain a competitive edge (Mergel et al., 2019; Dacre et al., 2019; Verhoef et al., 2021). However, despite being a foundational pillar of the global economy, the construction industry has significantly lagged in digital transformation. Ranked last alongside agriculture and hunting in terms of digitalisation among 22 industries (Dong et al., 2021a; Sezer et al., 2021), construction faces substantial challenges in adapting to digital transformation due to its project-based nature, where production, innovation, and competition hinge on individual construction projects (Hobday, 2000). Consequently, a construction firm's success in digital transformation depends heavily on its capacity to digitalise its project processes (Eggleton et al., 2021).

Digital transformation in construction commonly entails using technology to fundamentally enhance construction workflows, improve productivity, and deliver better project outcomes with increased client satisfaction (Adekunle et al., 2021). Numerous digital technologies, including building information modelling (BIM), autonomous robotics, cloud computing, 3D printing, the Internet of Things (IoT), augmented reality, and big data analytics (Kockum & Dacre, 2021), artificial intelligence (Dacre & Kockum, 2022a; Dacre et al., 2020; Hsu et al., 2021a; Hsu et al., 2021b), have begun to facilitate the digitalisation of construction projects, showing promising progress (Aghimien et al., 2020). While these technologies are poised to transform project delivery by increasing efficiency and productivity, their potential has not yet been fully realised (Miettinen & Paavola, 2014; Prebanic & Vukomanovic, 2021). For instance, BIM, one of the most widely adopted tools in construction, reveals a substantial gap between anticipated and actual benefits (Gu & London, 2010; Miettinen & Paavola, 2014; Hetemi et al., 2020). Although BIM is widely used for creating 3D models of building structures, its potential to enhance productivity, foster integrated workflows, and improve project delivery remains largely untapped (Miettinen & Paavola, 2014; Sinenko et al., 2021). In practice, digital technology in construction projects often supports only selective management functions rather than driving a transformative digital overhaul across entire projects or organisations.

Implementing digital transformation is far more than merely adopting new technologies; it demands technology-mediated organisational change encompassing shifts in organisational structures, business processes, and work methodologies (Bosch-Sijtsema & Gluch, 2021; Sinenko et al., 2021). This process is understood as sociotechnical, where technology and organisational dynamics must harmonise to maximise value creation and delivery (Greenan, 2003; Tilson et al., 2010; Zulu & Khosrowshahi, 2021). Yet, recent studies indicate that organisational factors often pose the most significant barriers to digital transformation in construction, manifesting in hostile inter-partner relations, inadequate policies and standards, ineffective management practices, and other challenging organisational conditions (Miettinen & Paavola, 2014; Bajpai & Misra, 2021). Consequently, construction organisations urgently require managerial reforms to better align digital technologies with organisational structures, thereby facilitating successful digital transformation (He et al., 2017; de Soto et al., 2019; Bosch-Sijtsema & Gluch, 2021).

Despite the crucial role of organisational factors, research on digital transformation within construction has predominantly concentrated on technical dimensions, such as the digital representation of projects (Cheng & Teizer, 2013; Elghaish et al., 2021), leaving a gap in understanding the influence of project management approaches on digital transformation, particularly from an organisational perspective. Traditional project management practices are increasingly unsuitable for digitalised construction projects, as digital transformation is predicated on the integration of data throughout the project life cycle, fostering new, cohesive ways of working (Miettinen & Paavola, 2014). The fragmented, decentralised nature of conventional project management obstructs stakeholder collaboration and limits digital technology's potential to integrate and share data seamlessly across the project life cycle (Forgues & Koskela, 2009). For digital transformation to fully benefit construction projects, the holistic, integrative qualities of digital technology must be embedded into the overall project management framework. Addressing this need, the present paper aims to investigate how digital technology and project organisation can be aligned through integrated project management practices to advance digital transformation in construction projects.

2. Theoretical background

2.1 Digital transformation of construction projects

Interest in the digital transformation of the construction sector has surged in recent years, fuelled by the impacts of the COVID-19 pandemic and the subsequent rise in remote working (Barber et al., 2021; Dacre et al., 2022; Eggleton et al., 2021; Sonjit et al., 2021a, 2021b, 2021c). The literature predominantly addresses digital transformation (Brookes et al., 2020; Dacre et al., 2015; Dacre et al., 2022; Dacre et al., 2019) in construction from the perspectives of industry-wide and organisational impacts, examining processes (Sadeh et al., 2021), technologies (Tibaut & Zazula, 2018; Silverio-Fernandez et al., 2021), strategies (Lundberg et al., 2021; Panenkov et al., 2021; Zulu & Khosrowshahi, 2021), and practical applications (Hautala et al., 2017; Gusakova, 2018; Succar & Poirier, 2020; Prebanic & Vukomanovic, 2021; Nikmehr et al., 2021). Nonetheless, there has been comparatively little focus on achieving digital transformation at the project level, a gap which requires further exploratory investigation.

According to extant literature, digital transformation within construction projects unfolds in three principal stages: digitisation, digitalisation, and digital transformation (Verhoef et al., 2021; Wernicke et al., 2021). The initial stage, digitisation, involves converting analogue information into digital formats (Gobble, 2018). Here, information technology (IT) is employed to support existing project tasks by collecting, storing, and processing data to aid decision-making and cost-effective resource allocation (Verhoef et al., 2021; Wernicke et al., 2021). Examples of digitisation include using digital tools to calculate quantities and software for tracking project progress (Brookes et al., 2020; Dacre et al., 2015; Dacre et al., 2019). However, in most cases, IT systems in this phase are limited to specific individuals or departments and seldom interconnect across the project (Ustundag & Cevikcan 2018; Santos & Martinho, 2019; Siedler et al., 2021). Thus, the impact of digitisation on project value creation remains limited (Dacre et al., 2014).

In the subsequent phase, digitalisation, digital technologies are integrated within projects to optimise processes (Nikmehr et al., 2021; Wernicke et al., 2021). With a range of digital tools, digitalisation enhances efficiency by fostering coordinated project processes (Gusakova, 2018). For example, building information modelling (BIM) enables early detection of design conflicts, reducing rework and associated costs (Aghimien et al., 2020).

During digitalisation, certain information and communication technology (ICT) systems are interconnected to facilitate information sharing among stakeholders and drive construction process improvements (Prebanic & Vukomanovic, 2021). However, while digitalisation supports efficiency gains, it does not yet represent a comprehensive transformation of work practices or a strategic deployment of digital technology across all project factors (Dacre et al., 2014; Dacre & Kockum, 2022b; Dong et al., 2022).

The final stage, digital transformation, signifies a profound shift in project delivery methods (Wernicke et al., 2021). Beyond digitalisation, this stage requires organisational restructuring to foster an optimal alignment with digital technology (Zulu & Khosrowshahi, 2021). In this phase, project processes, organisational structures, roles, and stakeholder practices are redefined, establishing an environment that enables digital technologies to facilitate new, integrated workflows (He et al., 2017; de Soto et al., 2019; Siedler et al., 2021; Bosch-Sijtsema & Gluch, 2021). A mature digital platform emerges at this stage, integrating project stakeholders horizontally and processes vertically across the entire project lifecycle, creating value for diverse stakeholders (Gusakova, 2018; Prebanic & Vukomanovic, 2021). Consequently, digital transformation enables construction organisations to develop core competencies and revolutionise value creation, significantly enhancing productivity and project delivery (Verhoef et al., 2021; Prebanic & Vukomanovic, 2021).

2.2 Project integration management

In project management, various tools and methods are employed to achieve project goals, with integration management being a crucial element (Rodney et al., 2015; Demirkesen & Ozorhon, 2017; PMBOK, 2017). Traditionally, "integration" refers to the process of combining elements to function in harmony (Lea & Bradbery). Within construction, integration typically addresses specific aspects such as process integration (Kamara, 2012), stakeholder integration (Hietajarvi et al., 2017; Saukko et al., 2019), or knowledge integration (Zhu & Gao, 2016; Yang et al., 2020). However, from a comprehensive perspective, project integration management in construction involves a project management approach that systematically integrates and coordinates all aspects of a project to meet stakeholder objectives (Wang et al., 2009; Liu et al., 2015; Al-Kuhail et al., 2021).

As contemporary projects grow increasingly complex (Dacre et al., 2020; Dong et al., 2021b), integration management has become essential for project success. Scholars have explored this from various angles. Halfawy and Froese (2007) developed a component-based framework for implementing an integrated architectural, engineering, and construction (AEC) project system, which enhances the consistency and integration of project information and processes. Ozorhon et al. (2014), through a case study, found that integrating project participants facilitates innovation by reducing barriers and consolidating innovation efforts. Rodney et al. (2015) introduced an integrated management approach, which merges risk management with project components, providing a more comprehensive approach to managing project risks. Similarly, Berteaux & Javernick-Will (2015) emphasised that AEC project organisations benefit from integrating knowledge and processes to adapt effectively to local contexts. Nonetheless, there remains limited research on how project integration management can support the digital transformation of construction projects (Dacre & Kockum, 2022a), and methods for implementing holistic integration management to advance digital transformation are not well-defined.

Several studies propose models of project integration management, divided into multiple dimensions. For example, based on Hall's (1969) three-dimensional structure, Wang et al. (2009) suggested a framework for construction project integration comprising process, control, and organisational integration. Liu et al. (2015) described integrated management as encompassing process, total factor, and all-round management. Additionally, Demirkesen & Ozorhon (2017) synthesised the literature to define six components of integration management: project charter development, process integration, knowledge integration, supply chain integration, staff integration, and change integration.

2.3 Three-dimensional project integration management framework

Drawing from this body of work, a three-dimensional project integration management framework has been developed, shown in Figure 1. This model defines project integration management across three dimensions, process integration, stakeholder integration, and knowledge integration, corresponding to Hall's temporal, informational, and logical dimensions. This framework will serve as an analytical lens in this study's case analysis to

investigate how project integration management can drive the digital transformation of construction projects.

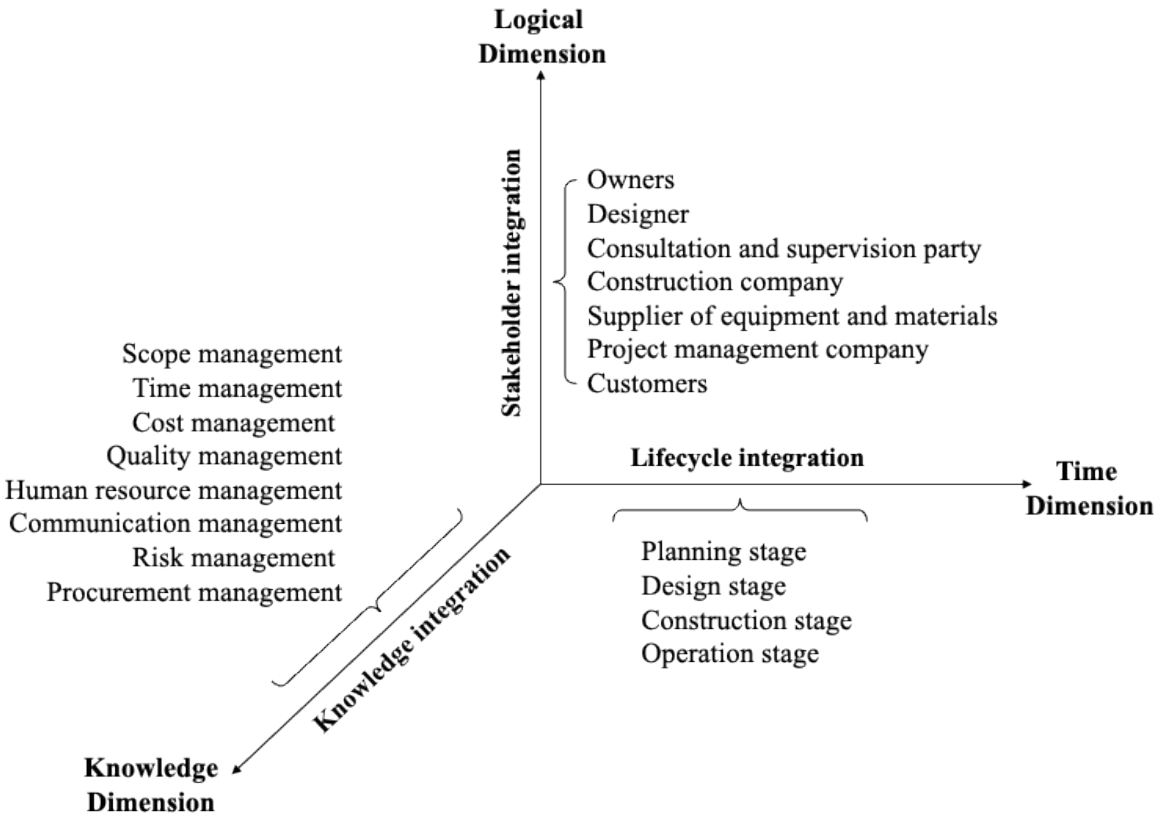

Figure 1: The framework of project integration management (adapted from Hall, 1969)

Process integration, aligned with the time dimension, addresses the need to synchronise various stages of the project life cycle—planning, design, construction, and operation (Demirkesen & Ozorhon, 2017). By emphasising seamless coordination across these stages, this dimension ensures that each phase contributes to a cohesive project trajectory, which is essential for successful digital transformation (Wernicke et al., 2021). In the case of the Inner Mongolia Minority Cultural and Sports Centre Project, process integration was achieved by implementing digital tools that connected these stages, facilitating real-time information flow and continuous alignment of project objectives (Eggleton et al., 2021). Effective process integration helps reduce fragmentation, a common issue in construction projects, thus fostering a smoother transition from traditional to digital workflows (Forgues & Koskela, 2009).

The logical dimension, represented by stakeholder integration, highlights the importance of bringing together diverse project participants—owners, designers, consultants, contractors, suppliers, and clients (Hietajarvi et al., 2017; Saukko et al., 2019). Digital transformation in construction projects often requires extensive collaboration among stakeholders to fully leverage the capabilities of digital tools (Prebanic & Vukomanovic, 2021). In this framework, stakeholder integration not only enhances communication but also promotes shared decision-making and collective responsibility, which are essential for managing complex projects in a digital environment (Zulu & Khosrowshahi, 2021). In this study's case project, integrating stakeholders through digital platforms facilitated better alignment of expectations and reduced miscommunication, supporting smoother project delivery (He et al., 2017).

Knowledge integration, aligned with the knowledge dimension, encompasses various management functions, such as scope, time, cost, quality, human resources, communication, risk, and procurement management (PMBOK, 2017; Zhu & Gao, 2016; Yang et al., 2020). This dimension ensures that knowledge generated and utilised throughout the project is effectively managed, shared, and applied across all stages and stakeholders. By fostering a culture of knowledge integration, construction projects can improve their adaptive capabilities, allowing project teams to respond quickly to challenges or changes (Berteaux & Javernick-Will, 2015). In the digital transformation context, knowledge integration is particularly vital, as it underpins the successful adoption and deployment of digital tools by providing a robust foundation of organisational learning and continuous improvement (Aghimien et al., 2020; Nikmehr et al., 2021).

This three-dimensional framework serves as a critical analytical lens for examining the Inner Mongolia project's approach to digital transformation. Specifically, by categorising integration into these three dimensions, the framework allows us to identify specific integration practices that support digital transformation, as well as the areas where alignment between digital tools and organisational practices is most effective (Bosch-Sijtsema & Gluch, 2021). As part of the ongoing research, we aim to further refine this model by examining additional case studies to test its adaptability and efficacy in diverse project environments.

3. Methodology

In order to provide a thorough analysis of complex social phenomena, this research employs a case study approach, following Yin's (2003) methodology. This method enables an in-depth examination of a single construction project to gain insights into the processes of project integration management for digital transformation (Dacre et al., 2019; Reynolds & Dacre, 2019). The chosen case for this study is the Inner Mongolia Minority Cultural and Sports Centre Project, a representative construction project in mainland China. Located in Hohhot, this large-scale and complex project has a total budget of €107 million. Faced with an exceptionally tight 15-month project schedule, the project management team implemented a "technology + management" approach, integrating management practices with digital tools to ensure timely delivery (Eggleton et al., 2021). This approach makes the project particularly suitable for exploring the research questions.

Primary data collection involved focus group interviews with a diverse range of project stakeholders, including project and general managers, project management team members, the project owner, contractors, clients, and other key stakeholders. A total of seven in-person focus group interviews were conducted, comprising 23 participants. Each session centred on a specific topic, such as the application of digital tools within the project, and participants were selected based on purposive sampling (Merton et al., 1956) (see Table 1). Interviews lasted between one and three hours and were recorded with the interviewees' consent. Additional data were collected through document analysis, reviewing materials such as project reports, minutes from milestone and issue-related meetings, commercial publications, research articles, news pieces, and online resources.

Guided by the previously established analytical framework, the data will be systematically organised and analysed to examine the integration management process across three dimensions: stakeholders, project life-cycle, and knowledge. This investigation aims to develop a project integration management model that supports the digital transformation of construction projects. The resulting model will facilitate an organisational transformation that better aligns with digital technology, providing a structured method for construction enterprises to drive digital transformation in their projects.

Table 1: Key information of focus group interviews

No.	Role & Number of Interviewees	Specific Interview Topic	Duration
1	Project owner (2)	Project objectives and the motivation for adopting digital transformation strategies	1.5 h
2	Project management company CEO (1)	The organisational design of the project in implementing digital transformation	1 h
3	Project manager / Deputy project manager (3)	The coordination of project processes and resources	2 h
4	Project technology director (1)	The application of digital tools and platforms in the project	1 h
5	Project management team members (5)	Management methods for implementing digital technologies in project tasks	2.5 h
6	Design company, consulting company, contractor, subcontractor, and supplier (10)	The participation and collaboration of stakeholders in the digital transformation of the project	3 h
7	Future user of the project (1)	Experience of using the project	1 h

4. Discussion and Future Research

4.1 Contribution to theory and practice

The findings offer preliminary contributions to the theoretical understanding of digital transformation in project-based sectors, particularly construction. While previous studies have largely addressed digital transformation at the industry and firm levels (Sadeh et al., 2021; Tibaut & Zazula, 2018; Lundberg et al., 2021), this research brings attention to the project level, illustrating how integration management can act as a foundational enabler. In this regard, by aligning organisational practices with digital technologies, projects can achieve enhanced synchronisation of resources and processes. The three-phase model of digitisation, digitalisation, and digital transformation (Verhoef et al., 2021; Wernicke et al., 2021) provides a useful framework for understanding these shifts; however, this case study highlights the critical role of project-specific factors, such as stakeholder engagement, agile management practices, and adaptive knowledge sharing, in successfully moving through these phases.

For practitioners, this study underscores the importance of a holistic, integrated approach to digital transformation in construction. The success of the Inner Mongolia project was not merely due to the use of digital tools but to the deliberate integration of these tools into the project's organisational structure and processes. Therefore, by involving stakeholders at multiple levels and using tools like BIM to facilitate real-time information sharing and decision-making, the project team was able to mitigate risks and streamline operations. As digital transformation in construction continues to evolve, practitioners should consider adopting integrated management frameworks that encompass all aspects of project execution, from planning to post-completion. This approach can help overcome common barriers in the industry, such as fragmented workflows, limited inter-departmental communication, and resistance to change (He et al., 2017; Bosch-Sijtsema & Gluch, 2021).

4.2 Limitations and future research directions

While this study provides valuable insights, it is based on a single case, which limits the generalisability of the findings. Future research should examine a broader range of construction projects, particularly those in varying cultural and regulatory contexts, to test the adaptability of the proposed project integration management model. Additionally, further investigation is required to explore the specific challenges and enablers of digital transformation at each stage, digitisation, digitalisation, and digital transformation, in different types of construction projects.

Future studies may also focus on the role of individual technologies in facilitating integration, such as BIM, IoT, and data analytics, to determine how each contributes to stakeholder engagement, process optimisation, and knowledge management within construction projects (Aghimien et al., 2020; Nikmehr et al., 2021). As part of the ongoing research process, we aim to refine the integration framework by identifying critical success factors and potential obstacles that impact the scalability of digital solutions across projects of varying scopes and complexities (Dacre, Eggleton, Gkogkidis, et al., 2021).

4.3 Developing a dynamic integration model

As digital transformation in construction remains a rapidly evolving field, future research must consider the potential for a dynamic integration model that adapts in real time to project demands and environmental changes (Dacre, Eggleton, Cantone, et al., 2021).

Given the current gap in literature on adaptive project integration management, we will explore how flexible, real-time integration mechanisms might support project managers in responding to unforeseen challenges, such as resource constraints, regulatory shifts, or technological disruptions. This line of inquiry will help to develop more resilient and adaptable frameworks, capable of sustaining project performance in increasingly digital and unpredictable environments (Dong et al., 2021a, 2021c; Tite et al., 2021a, 2021b).

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