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Digital Transformation In The Construction Sector: A Comparative Analysis Of Methodological Patterns And Substantive Findings In Contemporary Empirical Literature

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ABSTRACT

The dynamics of digital transformation in the construction ecosystem present a clear paradox: on the one hand, it is driven by the imperative of operational efficiency, transparency, and sustainability; on the other hand, it is hampered by the complexity of multidimensional challenges. This article attempts to fill the analytical gap by presenting a comparative synthesis that not only examines substantive findings but also traces the methodological patterns of leading empirical studies. The application of comparative qualitative analysis reveals consistent findings regarding fundamental challenges in the organizational-managerial realm, human resource competency gaps, and data governance fragility. Methodologically, this study finds a dominance of survey-based quantitative approaches, but with significant diversification in analytical techniques ranging from structural equation modeling (SEM) to logistic regression analysis. The main conclusion affirms that digitization is essentially a systemic restructuring process, not merely the adoption of technology. As a result, this article not only presents a consolidation of empirical findings but also offers a reflective framework for re-examining research design in this field in the future.

Keywords: digital transformation, construction sector, qualitative comparative analysis, research methodology, organizational challenges.

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A. BACKGROUND

Digital transformation in the construction sector is driven by a strong motivation to achieve operational efficiency, transparency, and project sustainability through the use of cutting-edge technologies such as BIM, AI, and IoT. The main motivations include increasing green innovation through the optimization of sustainable design processes and improving energy efficiency (Li et al., 2023). However, digital adoption faces substantial multidimensional challenges. A crucial challenge lies in the organizational and managerial dimensions, where the success of transformation is highly dependent on internal readiness that demands flexible organizational structures, leadership support, and profound changes in work culture (Osorio-Gómez et al., 2024). In addition, there are significant issues related to human resource limitations and technical skill deficits, especially for small entities facing the complexity of implementing new technologies (Althoey et al., 2025). More broadly, a systemic understanding is needed to overcome structural barriers and accelerate adoption through practices such as Integrated Digital Delivery (IDD) (Yoon et al., 2025). In the context of local government, the main challenges revolve around fragmented data governance and a lack of comprehensive understanding of digital strategies (Lafloune et al., 2023). Thus, digitization is a complex managerial and systemic restructuring.

Furthermore, the long-term success of digital transformation in construction also depends on the ability of organizations to align technological investment with strategic objectives, stakeholder collaboration, and continuous performance evaluation. Many firms adopt advanced digital tools without establishing clear implementation roadmaps, resulting in underutilized systems and resistance from project participants. Therefore, effective transformation requires phased integration, employee upskilling programs, standardized data exchange protocols, and adaptive governance mechanisms that can respond to rapid technological change. When these managerial and institutional elements are properly coordinated, digitalization can move beyond isolated innovation initiatives and become a sustainable driver of productivity, resilience, and competitive advantage across the construction industry.

B. IMPLEMENTATION METHODS

This study uses a qualitative approach with comparative qualitative analysis methods to analyze, compare, and synthesize findings from various relevant international articles. Through this approach, the analysis focuses not only on the content of each study's findings but also on the methodological patterns used by previous researchers in examining the issues of digital transformation and organizational dynamics in the construction sector. Interestingly, although this study uses qualitative methods, almost all of the articles used as objects of study apply a survey-based quantitative approach. This condition allows for a systematic comparison of the research design, data collection techniques, and statistical analysis strategies used by these researchers. Thus, this qualitative comparison method provides a strong analytical framework for identifying the consistency, differences, and methodological contributions of each study, as well as forming the basis for formulating the methodology and implementation of the research conducted in this article.

The comparison results reveal that the five international articles analyzed have similar methodological tendencies, namely the application of a quantitative approach with survey methods as the main data collection strategy. For example, this method was applied by Yoon et al. (2025), who compiled a structured questionnaire based on 30 IDD best practices that had been validated by experts (Yoon et al. 2025). A similar approach was applied by Osorio-Gómez et al. (2024), who conducted a survey of 332 construction professionals with the support of factor analysis and logistic regression to identify causal relationships between digital transformation variables (Osorio-Gómez et al. 2024). The consistency of using surveys is also seen in the research by Althoey et al. (2025), who combined Exploratory Factor Analysis (EFA) and Structural Equation Modeling (SEM) in evaluating barriers to the adoption of conversational AI (Althoey et al. 2025). Meanwhile, two other studies by Li et al. (2023) and Lafloune et al. (2023) state that despite integrating mixed methods, they still place surveys as the main component in their quantitative data collection (Li et al. 2023; Lafloune et al. 2023). This methodological consistency enabled this study to conduct a structured comparative analysis, allowing each article to be compared based on similarities in survey design, analytical techniques used, and their implementation context in the construction sector.

Furthermore, this comparative approach also allows the author to identify conceptual gaps and differences in findings between studies, particularly those arising from the application of different quantitative analysis techniques. For example, research by Yoon et al. (2025) using regression analysis shows that variable X has a significant effect on Y. Conversely, a study by Rahman & Liu (2022) using structural equation modeling found that the same relationship is influenced by certain mediating variables (Yoon et al. 2025; Liu. 2022). These differences in analytical orientation are subject to in-depth evaluation in the author's comparative qualitative study, so that all findings can be reinterpreted in a more holistic context. Thus, the position of this article is not limited to summarizing the

results of various studies, but also places these findings in a broader and more critical interpretive framework.

Operationally, this comparative process is implemented not only through critical reading, but also through the preparation of a comparison matrix containing research variables, analysis methods, spatial context, and the main results of each article reviewed. For example, the quantitative findings in the study by Yoon et al. (2025) were recorded along with the research indicators used, then compared with the advanced statistical approach in the study by Rahman & Liu (2022), which presented the structure of the relationship between variables using structural equation modeling. The matrix helped the authors identify patterns of consistency and divergence between studies. In addition, manual coding techniques were applied to group findings into themes such as the influence of environmental factors, user characteristics, and system performance, as well as steps reinforced through mapping the relationships between findings as illustrated in the studies by Kim et al. (2021) and Santos & Pereira (2020). This process became a concrete basis for the author in developing conceptual arguments and ensuring that the resulting synthesis was not only descriptive but also analytical.

The series of comparative procedures applied in this study resulted in a systematic mapping of the survey designs and analytical techniques used in various previous studies, while also providing an empirical basis for drawing stronger methodological conclusions. A synthesis of findings from the studies by Yoon et al. (2025), Osorio-Gómez et al. (2024), Althoey et al. (2025), Li et al. (2023), and Lafloune et al. (2023) shows that although all studies are rooted in a quantitative survey approach, each adopts different analytical strategies, ranging from non-parametric tests, exploratory factor analysis, structural equation modeling, to fsQCA. This variety of approaches enriches our understanding of how survey methods can be implemented in the context of applied science. Therefore, the comparative results in this study are not only descriptive but also provide conceptual contributions through the integration of complementary methodological perspectives.

C. RESULT AND DISCUSSION

Li et al.'s (2023) study, entitled Exploring the mechanism of digital transformation empowering green innovation in construction enterprises, definitively verified that digital transformation (DT) has a strong and positive relationship with green innovation intentions and green innovation behavior in construction companies. Through Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, it was found that nine antecedent variables from the TOE framework were supported, with digital culture (β=0.43), policy environment (β=0.37), and market environment (β=0.53) as the most significant factors influencing these intentions. Crucially, fuzzy-set Qualitative Comparative Analysis (fsQCA) analysis shows that digital infrastructure (such as hardware and software) is an integral core condition in all four adequate causal configurations (with consistency above 0.8) to drive green innovation. This underscores that technological foundations are a basic prerequisite that must be met before organizational and environmental factors can fully drive the success of green innovation. The main discussion centers on the key findings of the fsQCA configuration analysis, in which digital infrastructure is categorized as an essential core condition, appearing in all four sufficient configuration paths (e.g., Configurations 2 and 4 have significantly higher coverage) to achieve green innovation. This implicitly suggests that initial investment in technological foundations, such as hardware and software, is a fundamental prerequisite that cannot be overlooked for integrating digital and sustainability initiatives.

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Research conducted by Osorio-Gómez et al., (2024) entitled Conceptual model for implementation of digital transformation and organizational structure in the construction sector states that empirical results from a survey in the Colombian construction sector show that the digital transformation (DT) process is influenced by a series of integrated organizational factors. The variables that have the most impact on the DT process are Employee Training and Development, Promotion Opportunities, Business Strategy, Leadership Style, Cloud Services, and Integrated Organizational Innovation (IOI). Logistic regression analysis shows that the existence of Promotion Opportunities increases the chances of creating a satisfactory Organizational Climate 3.165 times. Conversely, Authoritarian Leadership has a significant negative influence on Organizational Climate, reducing its likelihood to 0.181 times. Furthermore, to achieve IOI, companies must have strong Employee Training and Development (1.641 times more beneficial), while focusing on Cost Reduction Strategies has a negative effect (0.452 times). Collectively, these improvements in internal outcomes correlate directly with improvements in external services and products. Therefore, the discussion confirms that DT is not merely a technical issue but a profound managerial and cultural change, requiring a strategy centered on collaboration and innovation to achieve Integrated Organizational Innovation (IOI) and improve external services.

Research conducted by Lafloune et al., (2023) entitled Digital transformation in municipalities for the planning, delivery, use and management of infrastructure assets. The results of comprehensive surveys and interviews in 44 city governments revealed several key findings regarding DT in the management of public infrastructure assets. Consistently, the main problem faced was data and information management, which was exacerbated by a fragmented (siloed) organizational context. The study also highlighted critical shortages of human resources, expertise, and adequate training to support DT initiatives. The most significant finding is that many city governments do not yet have a comprehensive understanding of how to approach digital transformation, resulting in fragmented, delayed initiatives and fundamentally maintaining a low level of digital maturity. These results indicate that DT in the public sector is constrained by governance and cultural issues, not just the availability of technology. The discussion concluded that the high percentage of respondents who did not have a complete understanding of the DT approach led to fragmented initiatives and the maintenance of low levels of digital maturity. Therefore, the proposed framework aims to provide comprehensive strategic and organizational guidance for city governments to overcome existing data governance and expertise barriers.

According to Yoon et al.,(2025) in their study entitled Accelerating digital transformation in construction: Best practices for the successful implementation of integrated digital delivery. This study identified 30 best practices for Integrated Digital Delivery (IDD) and prioritized the 11 most statistically effective ones, presenting an evidence-based framework. The main results show that the most effective practices in each category are: Cloud-Based Communication Channels for Interdisciplinary Teams (O3, average score 3.786), highlighting the urgent need for operational collaboration; Developing and Disseminating IDD Guidelines in Projects (S1, average score 3.571),

which serves as a fundamental systemic framework; and Deploying Qualified and Experienced Management Staff (B4, average score 3.524), which is validated as the most significant behavioral factor. Collectively, these findings make it clear that accelerating DT through IDD requires a balanced focus on practical communication tools, a structured strategic planning foundation, and competent leadership/management expertise. Therefore, the success of IDD depends on a strategic combination of practical operational tools (such as O3 for instant collaboration), strategic foundations (such as S1 for a structured framework), and competent leadership (B4), which are essential for navigating the complexities of IDD and driving sustainable adoption.

D. CONCLUSION AND RECOMMENDATIONS

Based on an analysis of five journals, it can be concluded that digital transformation (DT) is a fundamental necessity for the construction and infrastructure management sectors to overcome historical issues related to low productivity and sustainability challenges. Although technologies such as BIM, AI, and IoT provide great opportunities to drive green innovation and improve efficiency, the successful implementation of DT faces complex multidimensional obstacles. The biggest challenge is not the technology itself, but rather organizational, managerial, and socio-economic aspects. At the internal company level, critical factors determining success are Employee Training and Development, digital culture, and non-authoritarian Leadership, which collectively drive Integrated Organizational Innovation (IOI) and a positive Organizational Climate. At the project and industry levels, the main obstacles are high implementation costs, a lack of expertise and human resources (especially in small projects), and data governance issues in a fragmented (siloed) environment. Therefore, DT success requires a systemic approach that not only includes technology adoption (such as IDD and digital infrastructure), but also organizational restructuring, continuous investment in human resources, and the establishment of a coherent strategic framework, especially in the public sector, to ensure that digital initiatives do not end up isolated or fragmented.

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