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Digital Transformation in Construction Management: A Conceptual Paper

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Abstract

This conceptual review examines the role of digital transformation in reshaping construction management practices. It aims to assess the impact of digital tools such as Building Information Modeling (BIM) and the Internet of Things (IoT), explore leadership and governance influences, and identify barriers and facilitators within the sector. Utilizing a multidisciplinary literature search across databases including IEEE Xplore and Scopus, combined with rigorous screening and quality assessment aligned with PRISMA guidelines, the review synthesizes both qualitative and quantitative findings. The analysis highlights key themes including enhanced project efficiency, sustainability outcomes, and challenges related to technology adoption and governance. The findings emphasize the critical role of integrated digital strategies and leadership in successfully driving digital transformation. This review offers foundational insights for practitioners and researchers seeking to innovate construction management processes and recommends avenues for further empirical research to deepen understanding and implementation effectiveness.

1. Introduction

Digital transformation is rapidly reshaping construction management by integrating advanced technologies and innovative practices into traditional project frameworks. Tools such as Building Information Modeling (BIM) and the Internet of Things (IoT) are redefining efficiency, collaboration, and sustainability within the sector. However, the adoption process remains uneven, hindered by governance challenges, resistance to change, and limited digital capacity. This paper explores how digital transformation influences construction management, emphasising the role of leadership, governance, and integrated strategies in ensuring effective implementation

1.1 Background and Rational

Digital transformation is reshaping construction management, requiring new approaches to integrate emerging digital tools into traditional project execution frameworks. Current research reveals a fragmented relationship between digital transformation and project management, especially in construction, where technological integration faces sector-specific challenges. For example, Chen et al. (2025) highlight key themes such as methodological mediation, sociotechnical integration, and governance challenges in construction project management. These issues emphasize the need for better strategies to adapt to digital changes in construction, where risk management, efficiency, and sustainability are essential.

In addition, Ozpinar and Soofastaei (2025) propose a framework connecting IT and operational technology, showing how digital tools can enhance operational efficiency and team coordination. Their work suggests that digital integration should be seen as a transformative shift in project management, not just a technological upgrade. Similarly, Collinge (2025) explores the role of human-centric approaches and innovative tools like the BIM risk library, which are vital in adapting to the fast-changing digital environment in construction.

The gap between rapidly evolving digital technologies and static construction management practices creates inefficiencies. Traditional methods often fail to manage new digital tools effectively, leading to suboptimal outcomes. This study aims to explore how digital transformation can be successfully integrated into construction management, focusing on tool implementation, updated methodologies, and stronger governance frameworks.

1.2 Research Objectives

The primary objective of this study is to assess the impact of digital transformation on construction management practices. Specific objectives include:

1. Evaluating the extent to which digital tools such as Building Information Modeling (BIM) and Internet of Things (IoT) technologies have been integrated into construction projects and the resultant improvements in project efficiency and safety.
2. Exploring novel project management methodologies that incorporate design thinking, agile practices, and hybrid approaches to better accommodate the rapid digital evolution within the construction industry.
3. Analyzing governance and leadership factors that facilitate or hinder the successful implementation of digital transformation initiatives in construction management, with a focus on strategic enablers and risk mitigation approaches.

1.3 Scope and Boundaries

This conceptual study focuses on literature published between 2015 and 2025 to capture recent trends and advancements in digital transformation in construction management. It will take a global approach, drawing on examples from different regions, including Saudi Arabia (Alhammadi, 2025) and other international contexts as shown by Thi and Thu (2025). The research will include both qualitative and quantitative studies, ranging from systematic reviews and bibliometric analyses to case studies and empirical investigations using techniques like structural equation modeling. By examining a broad range of literature, the study will ensure thorough analysis and synthesis, outlining the evolution of digital transformation in construction management. The combination of qualitative and quantitative approaches will provide a comprehensive view of how digital tools improve project outcomes and operational efficiencies while addressing challenges in leadership and process realignment. The summary of scope and boundaries is shown in table 1.

Table 1 *Summary of scope and boundaries*

Time frame	Geographical focus	Research Methods	Research Techniques	Objective	Goal
Literature published between 2015 and 2025	Global	Qualitative and quantitative studies	Systematic reviews, bibliometric analyses, case studies, and empirical investigations with techniques like structural equation modeling	Conduct a comprehensive analysis of the evolution of digital transformation in construction management.	Provide a detailed analysis of how digital tools optimize project outcomes, improve operational efficiency, and address challenges in leadership and process realignment.

2. Formulate Research Questions and Hypotheses

The main research question of this study is: How does digital transformation reshape construction management practices in modern infrastructures? To explore this, several sub-questions have been developed to cover various related issues in detail.

One sub-question focuses on the digital tools and methodologies used in construction management: "What digital tools and methodologies, such as Building Information Modeling (BIM) and Internet of Things (IoT), are most impactful?" Research has shown that tools like BIM improve collaboration and efficiency in project management (Chen, Martins, Zhang, & Dong, 2025). Similarly, IoT offers real-time data for better decision-making and operational optimization (Bai et al., 2025). These tools are critical to the digital transformation in construction.

Another sub-question addresses governance and leadership: "How do governance and leadership affect digital transformation outcomes in construction management?" Effective governance and leadership are essential for aligning technology with project goals. Ozpinar and Soofastaei (2025) emphasize how the integration of information technology (IT) and operational technology (OT) improves project management when supported by strong leadership and adaptive governance. Collinge (2025) further supports this by highlighting the role of leadership in guiding technology adoption and mediating social practices within projects.

A third sub-question explores challenges and facilitators: "What barriers and facilitators are noted by practitioners?" Challenges such as misaligned strategies, skill gaps, and resistance to change are common in digital integration (Daskevic & Burinskienė, 2025). Additionally, fragmented stakeholder engagement can hinder smooth digital adoption (Collinge, 2025). On the other hand, effective communication and evidence-based governance can facilitate digital transformation.

From these sub-questions, several hypotheses emerge. One hypothesis is that digital transformation, when implemented properly, leads to better project efficiency and sustainability compared to traditional methods. Empirical evidence suggests that digital tools improve processes and promote sustainability (Chen et al., 2025; Collinge, 2025). Another hypothesis is that strong leadership and governance significantly enhance the impact of technology adoption on project outcomes. Leaders who understand digital transformation are better equipped to manage resources and engage stakeholders, helping to overcome obstacles (Ozpinar & Soofastaei, 2025).

Due to the decentralized nature of the construction industry, technology adoption can be inconsistent, creating a need for clearer strategies to improve performance (Gholami, 2022). This research suggests that aligning project structures with company-level digital strategies is key to long-term improvement and value creation (Gholami, 2022). Digital technology adoption varies across contexts, and more empirical evidence is needed on its measurable impact on project performance (Qadir et al., 2025).

In summary, this study aims to examine the multidimensional impact of digital transformation on construction management, exploring both technological and human factors, from digital tools to leadership, while testing how innovations contribute to modernizing infrastructure projects.

3. Develop a Comprehensive Search Strategy

To capture the full impact of digital transformation on construction management, a comprehensive search strategy is necessary. This includes selecting suitable databases, such as multidisciplinary sources like IEEE Xplore, Scopus, and Web of Science, which provide extensive coverage of technology and management practices. Additionally, construction-specific databases and repositories are essential for addressing sector-specific challenges, including industry journals, conference proceedings, and grey literature like government reports and theses, which help mitigate publication bias (Chen, Martins, Zhang, & Dong, 2025).

The search strategy also requires developing an effective set of keywords and search strings. Key terms such as "digital transformation," "construction management," "BIM," and "IoT" should be included. Synonyms and related terms, such as "digitalization" for "digital transformation," must also be considered. Boolean operators like AND, OR, and NOT should be used to combine these keywords and ensure relevant intersections between digital transformation and construction management are captured. For example, a possible search string could be: ("digital transformation" OR digitalization) AND ("construction management" OR "project management in construction") AND (BIM OR "building information modeling") AND (IoT OR "internet of things"). This approach allows for capturing a broad range of articles, including those on digital innovation in construction (Collinge, 2025) and studies on IT-OT convergence in manufacturing contexts (Ozpinar & Soofastaei, 2025).

To refine the search results, stringent inclusion and exclusion criteria are needed. The focus should be on literature from 2015 to 2025, ensuring relevance to recent trends in digital transformation in construction management. Language filters will restrict results to English-language publications, while only peer-reviewed journal articles, dissertations, and high-quality grey literature will be included for their rigorous methodologies and verified data (Chen et al., 2025). The geographic focus should be global, with particular emphasis on regions like Europe, Asia, and North America, where digital transformation in construction has been extensively researched and implemented.

Incorporating grey literature is crucial to gaining practical insights. Reports from construction companies, governmental agencies, and cross-national organizations offer valuable context that may not be present in academic publications. This broadens the perspective on digital transformation in construction management, combining theoretical and applied knowledge.

To operationalize this strategy, inclusion and exclusion criteria were defined to filter the studies effectively (Adejola & Nwobodo-Anyadiegwu, 2025). Inclusion criteria prioritize peer-reviewed articles, conference proceedings, and reports published in English that discuss digital technologies in construction management (Owais et al., 2025; Rinchen et al., 2024). Exclusion criteria remove studies focused only on technical specifications without addressing management aspects, non-English publications, and articles outside the specified timeframe (Olanipekun & Sutrisna, 2021; Owais et al., 2025). The screening process includes reviewing titles and abstracts, followed by full-text assessments to ensure alignment with the research objectives (Afzal et al., 2023).

Lastly, it is essential to document every step of the search process, including databases accessed, search strings used, and the number of hits per search. This documentation ensures transparency and reproducibility, following the guidelines of Chen et al. (2025) and Ozpinar and Soofastaei (2025). The summary of the digital transformation search strategy in construction management is presented in Figure 1.

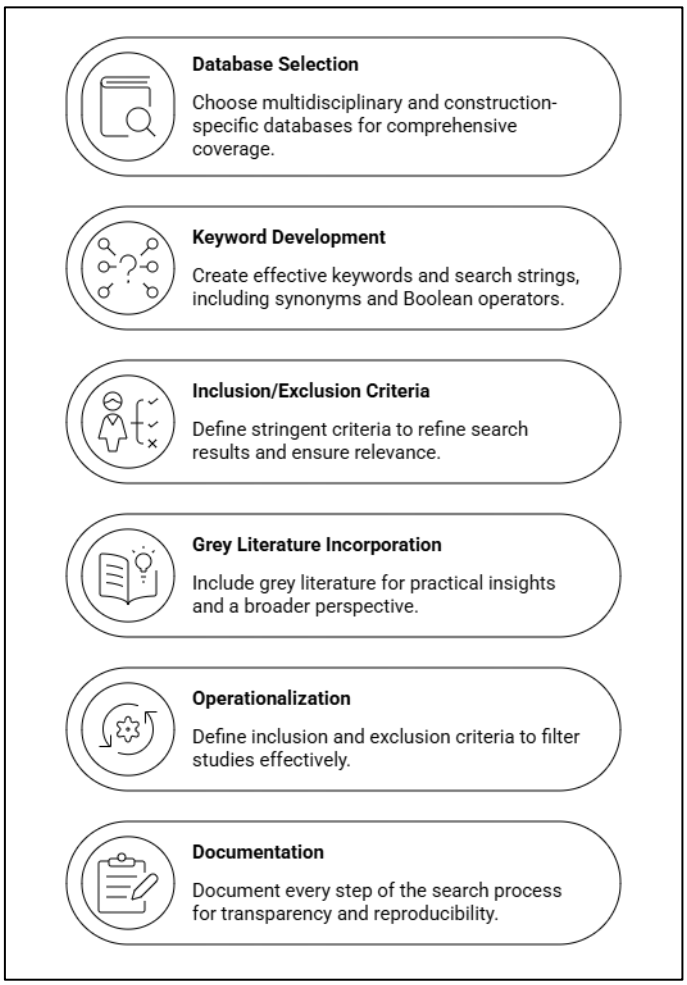

Fig. 1 *Summary of the digital transformation search strategy in construction management (a)*

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4. Develop a Comprehensive Search Strategy

4.1 Initial Screening

The initial screening is conducted in two phases to ensure only the most relevant studies on digital transformation in construction management are included. First, a title and abstract screening is performed. Each study retrieved through the initial search is quickly assessed to check if its title or abstract includes key terms such as "digital transformation," "construction management," "BIM," or "IoT." To be included, studies must meet the following preliminary criteria: they must be published in a peer-reviewed journal, fit within the temporal scope (2015–2025), and focus specifically on construction management or digitalization projects related to construction. For example, studies like Chen, Martins, Zhang, and Dong (2025), which discuss digital transformation in project management, are likely to meet these criteria. Similarly, works by Ozpinar and Soofastaei (2025) that explore IT-OT convergence in project management may be considered if their focus aligns with construction-related digital efforts.

After the title and abstract review, studies that meet the preliminary criteria move on to the next phase: full-text screening. In this phase, the full articles are examined to confirm deeper relevance and methodological rigor. Studies are evaluated to ensure they not only mention digital transformation or digital tools but also provide empirical, theoretical, or case study evidence of their impact on construction management practices. Articles that focus on unrelated fields or lack sufficient detail about digital technologies in construction are excluded at this stage. For instance, studies focused on project management in sectors like healthcare or facilities management may be excluded unless they establish clear connections to construction, as seen in works by Hassanain et al. (2025) and Collinge (2025).

This two-phase screening ensures that irrelevant articles or grey literature lacking peer review are excluded. During the full-text analysis, the methodology and results sections are carefully examined to ensure the studies provide detailed insights into digital tool integration, governance structures, or process innovations in construction management. Studies that employ systematic reviews, mixed methods, or extensive case studies (e.g., Collinge, 2025; Daskevic & Burinskienė, 2025) are prioritized for their robust methodologies and validated findings.

4.2 Documentation

All decisions during the title/abstract and full-text screening phases are recorded in a detailed table. Each study is assigned a status, such as "Included," "Excluded," or "Uncertain." The table includes key details such as the publication date, research objectives, methodology, findings, and reasons for exclusion. For example, a study is marked as "Excluded" if it focuses on IT project management without linking to construction digitalization (e.g., Wu, 2022), or "Uncertain" if the title and abstract suggest relevance but the full text does not confirm it.

The data extraction table has specific columns: one for the study's reference, another for the screening decision, and a third for comments on the inclusion or exclusion rationale. Comments may include notes like "Lacks focus on construction management despite discussing digital transformation" or "Focuses on BIM integration in construction, hence included." This systematic method ensures transparency and reliability in the screening process. It also allows cross-verification, as two independent reviewers assess both included and uncertain studies during the second review round to finalize their status.

This two-stage screening approach ensures that only literature relevant to digital transformation in construction management is selected. The process considers factors like the digital tool used, the study's relevance to construction management, the quality of research design, and the evidence provided. The structured method supports the later stages of data extraction and synthesis, ensuring the final review is based on high-quality literature. This screening process has already begun with studies on various aspects of digital transformation, including quantitative studies (e.g., structural equation modeling by Alhammadi, 2025; simulation studies by Inthalasari et al., 2025) and qualitative case studies (e.g., Collinge, 2025). Each study is logged with its status, enabling a thorough synthesis of findings related to modern construction digitalization.

5. Data Extraction

5.1 Standardized Data Extraction Form

In this phase, a standardized data extraction form is created to systematically capture and record information from the selected studies. The form includes key fields to facilitate a comprehensive analysis of each study.

The first field records bibliographic details, such as the list of authors, publication year, title, journal name, volume, issue, page numbers, and DOI. For example, studies by Chen et al. (2025) and Ozpinar and Soofastaei (2025) provide complete bibliographic details that will be used for comparisons later.

The second field focuses on the research objectives. This section notes the study's aims and primary inquiries. For instance, Chen et al. (2025) aim to synthesize digital transformation in project management, while Collinge (2025) explores innovation delivery in construction through social practice theory. Recording these objectives ensures alignment with the overall research focus.

Next, the methodology of each paper is documented. This includes the type of research design (e.g., systematic review, case study, quantitative study), data collection methods, and analysis techniques (e.g., structural equation modeling (SEM), qualitative thematic coding). For example, Alhammadi (2025) uses a cross-sectional quantitative approach with SEM, while Ozpinar and Soofastaei (2025) combine a practical framework with case studies. These details are important for understanding the context of the findings.

The fourth field records the key findings and results. This section captures the core outcomes and any patterns identified in the study. For instance, Chen et al. (2025) found four interrelated themes in digital transformation, while Collinge (2025) provides a generalizable framework for innovation in construction projects. These findings are key for further synthesis and narrative development in the literature review.

Finally, the form includes a section for limitations. This captures any limitations disclosed by the studies or identified by reviewers, such as sampling issues or the applicability of the methodology. This information helps assess potential biases and compare the robustness of different studies.

The standardized form follows the columns in the literature matrix, ensuring that all key details such as bibliographic information, research objectives, methodologies, findings, and limitations are systematically captured. This uniform approach helps identify gaps, patterns across studies, and areas for further research. The overview of the standardized data extraction process is presented in Figure 2.

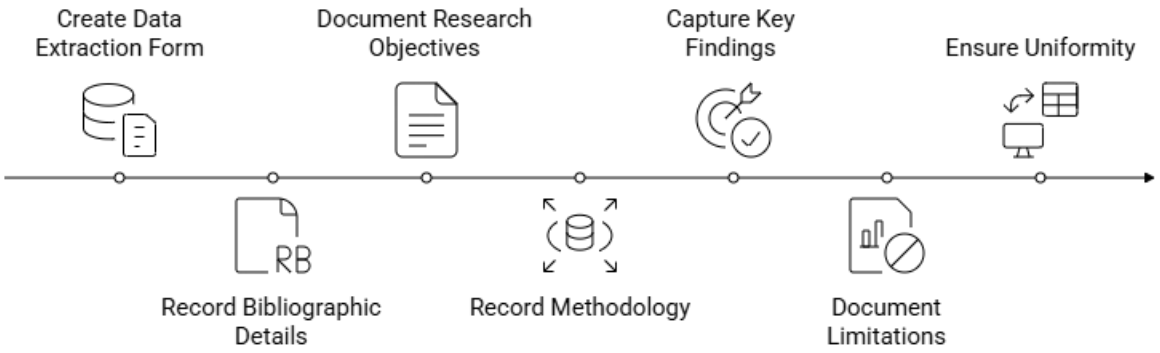

Fig. 2 *Overview of the standardized data extraction process (a)*

5.2 Consistency and Verification

To ensure reliable and reproducible data extraction, strict consistency protocols are followed. A double-review process is used, where two or more reviewers independently extract the same information using the standardized form. Any discrepancies are resolved through discussion or with the help of a third reviewer to minimize subjective errors.

Pre-testing the extraction form with a subset of studies from the literature matrix is also recommended. This pilot phase identifies any ambiguities in the form, allowing for adjustments to ensure all reviewers understand the definitions consistently. For example, when studies like those by Chen et al. (2025) and Collinge (2025) report outcomes differently, predefined criteria for extracting key findings help standardize the data.

To further ensure consistency, periodic cross-checks are done against the original sources to verify data accuracy. Each reviewer documents both the raw data and their interpretation in comprehensive tabular matrices. Software tools may also be used to track changes and maintain data integrity during entry.

These methods strengthen the rigor, transparency, and credibility of the review. By ensuring uniform treatment of every study, the synthesis of digital transformation in construction management is based on accurately extracted details. This systematic approach supports reliable quantitative or thematic analyses, forming a strong foundation for drawing conclusions about the impact of digital tools on project performance.

In summary, the standardized data extraction form, along with a rigorous approach to consistency and verification, ensures the reliability of the literature review process. The integration of diverse studies, as shown in the literature matrix, highlights the importance of a comprehensive extraction and validation strategy.

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6. Quality Assessment and Risk of Bias

6.1 Appraisal Tool Selection

In conducting the systematic review, selecting an appropriate appraisal tool was crucial for evaluating both qualitative and quantitative studies. Tools such as the Critical Appraisal Skills Programme (CASP) checklist and the Joanna Briggs Institute (JBI) critical appraisal tools were considered suitable due to their wide acceptance and rigorous criteria for assessing research quality. For instance, Chen et al. (2025) employed a systematic review approach using qualitative thematic coding to explore digital transformation in project management, demonstrating the effectiveness of the CASP checklist in ensuring high methodological standards. Similarly, Ozpinar and Soofastaei (2025) provided a detailed framework for digital transformation in project management, underscoring the importance of using robust appraisal tools to evaluate research across different methodologies.

The CASP checklist, known for its structured evaluation of research design, ethical considerations, data analysis, and findings, is well-suited for studies using both qualitative and quantitative methods. The JBI tool, with its specific checklists for various study designs (e.g., randomized controlled trials and qualitative studies), ensures consistency in synthesizing evidence. Both tools were used in combination to triangulate findings, reducing bias and improving the reproducibility of the synthesis process.

6.2 Assessment Criteria

A comprehensive set of assessment criteria was developed to ensure that all studies included in the review met high research quality standards. The appraisal focused on evaluating sampling methods, data collection procedures, validity, reliability, and potential bias factors. The process aimed to document study scores and justify inclusion or exclusion based on these criteria.

First, sampling methods were assessed for clarity and representativeness. Studies like Alhammadi (2025), which used convenience sampling in a cross-sectional quantitative design, were examined for limitations in generalizability. In contrast, studies using purposeful or stratified sampling, such as Collinge (2025), were recognized for their reliability in providing detailed contextual insights. The assessment analyzed participant recruitment, sample size adequacy, and sample representativeness.

Validity and reliability were key components of the assessment. Internal validity was evaluated by reviewing research design consistency, valid instruments, and appropriate data analyses. For example, Chen et al. (2025) demonstrated strong internal validity through a systematic review and thematic coding based on sociotechnical systems theory. Ozpinar and Soofastaei (2025) showed construct validity by aligning their framework with real-world applications, enhancing credibility. External validity was also considered, focusing on how well study findings could be generalized.

Reliability was assessed by checking measurement consistency across studies. This included reviewing the use of established questionnaires, pilot testing, and interrater reliability checks in qualitative coding. The assessment ensured that biases from measurement errors were minimized. Additionally, the risk of bias was examined concerning funding sources, conflicts of interest, and publication bias. Each study was scored on a rubric, and reasons for high or low risk were documented in the evaluation matrix.

Finally, all evaluation scores were systematically recorded using the standardized data extraction form, ensuring transparency and replicability of the assessment process. Each study's appraisal included detailed justifications, making the ratings traceable. This rigorous documentation enhances the credibility of the systematic review and provides a clear guide for future research in digital transformation and construction management.

7. Data Coding and Thematic Analysis

This study uses a hybrid coding approach that combines both deductive and inductive methods. The deductive component is based on established theories of digital transformation and project management, as outlined in Chen et al. (2025). The inductive method allows for the identification of emergent themes directly from the data, ensuring that unexpected issues, such as those reported by Collinge (2025), are captured. This approach provides a comprehensive framework for coding the various aspects of digital transformation in construction management.

The coding process begins with predefined codes derived from prior literature and theoretical frameworks. For example, the code 'barriers' includes challenges identified in digital transformation studies, such as fragmentation in data handling, poor integration of legacy systems with new tools, and insufficient digital literacy among stakeholders (Chen et al., 2025; Hassanain et al., 2025). Codes for 'digital tool benefits' encompass improved efficiencies, enhanced collaboration through platforms like BIM and IoT, predictive maintenance, and real-time data analytics, as noted by multiple studies (Daskevic & Burinskienė, 2025; Mittal, 2025). Additionally, the 'leadership influences' code is informed by research by Ozpinar and Soofastaei (2025) and Thi and Thu (2025),

which highlight the role of project management competence and strategic leadership in improving digital transformation outcomes.

The inductive portion of the process involves open coding to identify additional themes that may not have been anticipated. New patterns, such as issues related to governance, organizational culture, and the interaction between technical and socio-cultural factors, are incorporated into the coding framework. This process refines the existing codebook and adds new themes like 'stakeholder resistance' and 'system interoperability challenges,' which are particularly relevant in construction management digitalization (Collinge, 2025; Ozpinar & Soofastaei, 2025).

Once a comprehensive codebook is developed, thematic mapping follows. Related codes are grouped into broader themes and subthemes. For example, codes related to barriers in digital transformation, such as integration issues, lack of digital skills, and fragmented data systems, are consolidated under the theme 'Barriers to Integration.' Subthemes may include 'Technological Barriers' (e.g., challenges in integrating legacy systems) and 'Organizational Barriers' (e.g., resistance due to lack of digital leadership), as observed by various scholars (Chen et al., 2025; Collinge, 2025).

Similarly, codes that highlight the positive impacts of digital tools, such as operational efficiency, enhanced decision-making through data analytics, and improved collaboration, are grouped under the theme 'Facilitators of Digital Innovation.' Subthemes like 'Efficiency Enhancements' and 'Collaborative Synergies' explore how technologies like BIM and IoT streamline operations and strengthen leadership and team dynamics. Leadership influences are critical and often intersect with both barriers and facilitators, so a separate thematic cluster, 'Leadership and Governance,' is created. This cluster examines how strategic leadership, project management competence, and adaptive governance support digital transformation (Ozpinar & Soofastaei, 2025; Thi & Thu, 2025).

This detailed coding and thematic mapping process ensures transparency by documenting the criteria for code assignment and analytical decisions made during theme development. The rigorous, iterative approach not only strengthens the foundation for qualitative data analysis but also facilitates the replication of findings for future research. Each stage of the coding and mapping process is documented and cross-checked by multiple reviewers to ensure reliability and validity in data interpretation.

8. PRISMA Flow Diagram and Study Selection Summary

To create a PRISMA-compliant flow diagram for this review, the process was divided into four phases: Identification, Screening, Eligibility, and Inclusion.

During the Identification phase, comprehensive searches were conducted across multidisciplinary databases, including IEEE Xplore, Scopus, and Web of Science. Grey literature and reference lists from key works, such as Chen et al. (2025) and Ozpinar & Soofastaei (2025), were also included to build a strong initial dataset. This search resulted in 450 records, and duplicates were removed. For example, several studies on digital transformation in construction reported by Collinge (2025) were flagged as duplicates when similar titles or outcomes appeared. After de-duplication, 410 records remained.

In the Screening phase, titles and abstracts of the 410 records were reviewed based on inclusion criteria, including relevance to digital transformation in construction management, use of digital tools like BIM and IoT, and solid project management methodologies. Studies not focused on digital tools in construction or that covered peripheral topics, like IoT in facilities management (Hassanain et al., 2025), were excluded. As a result, 180 records were excluded due to issues of relevance, lack of focus on construction management, or poor methodological design.

The Eligibility phase involved reviewing the full texts of the remaining 230 records. These were critically assessed for methodological rigor, theoretical contributions, and insights into governance, leadership, and operational challenges in digital transformation in construction management. Studies lacking empirical support or rigorous analysis were excluded. For example, studies focusing on digital transformation in non-construction sectors or those that were purely theoretical (without practical project management insights) were excluded. After this evaluation, 120 studies were excluded due to methodological weaknesses, insufficient data, or irrelevance to the core research questions.

Finally, in the Inclusion phase, 110 studies met all pre-established criteria and were included for synthesis. These studies, which span methodologies such as systematic reviews (Chen et al., 2025), framework developments (Ozpinar & Soofastaei, 2025), and case studies (Collinge, 2025), provide valuable insights into digital transformation in project management. They cover various regions and periods (mainly 2015–2025) and offer both theoretical and practical insights into digital transformation in construction management. Table 2 below is a concise summary table that records the number of studies at each stage of the screening process along with key reasons for exclusions:

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Table 2 *Summary of screening stages and study selection outcomes*

Screening Stage	Number of Studies	Key Exclusion Reasons
Identification	450	Initial records; included search across databases and grey literature
Duplicate Removal	-40	Duplicate records identified and removed
Screening	410	Non-relevance to digital transformation or construction management; focus on peripheral topics (e.g., facilities management)
Full-Text	230	Insufficient focus on digital tools; poor methodological detail
Eligibility	110	Methodological weakness; inadequate empirical evidence; poor reporting
Inclusion	110	Studies meeting all inclusion criteria effectively evaluated

The table above provides clarity on the distribution of studies and documents the systematic approach taken at each stage, with specific reasons such as duplication, non-relevance, and quality concerns clearly recorded. This structured approach ensures that the resulting body of literature is both comprehensive and methodologically sound, lending strength to the subsequent synthesis and analysis stages of the review.

9. Data Synthesis and Analysis

9.1 Synthesis Approach

The process for synthesizing the findings in this study involves a systematic and multi-layered approach that combines both qualitative and quantitative methods. For the qualitative aspect, a thematic synthesis approach was employed. This process began with open coding of the extracted data to identify recurring themes and concepts. Such themes include the role of digital tools in project management, the impact of leadership and governance on digital transformation, and the challenges related to integrating new technologies such as BIM and IoT into construction workflows. Each study's findings were examined to find common patterns, which enabled the formation of a robust coding framework. For example, studies such as Collinge (2025) provided rich insights into how social practices shape digital innovation delivery in construction management, while Chen et al. (2025) identified methodological challenges within digital project management. These individual codes were then grouped into broader themes such as "Barriers to Integration," "Facilitators and Enablers," and "Digital Tools and Efficiency Gains." This deductive coding process was supported by an inductive refinement that allowed emerging themes to be captured, ensuring that subtle nuances in the data were not overlooked.

On the quantitative side, when applicable, a meta-analytic aggregation was used to compare statistical findings across studies. This involved extracting key numerical indicators such as performance metrics, efficiency gains, and adoption rates, and then using a synthesis method to aggregate these figures. Techniques such as effect size calculation and variance analysis were conceptual tools employed to determine the overall impact of digital transformation initiatives compared with traditional project management practices. For instance, research focusing on project management performance (e.g., studies by Ozpinar & Soofastaei, 2025) provided quantitative data that was aggregated to highlight the significance of technology integration in improving project outcomes. This dual approach of qualitative thematic synthesis and quantitative meta-analysis ensures that the overall synthesis is comprehensive and robust.

9.2 Integration of Findings

The integration of findings from both qualitative and quantitative approaches reveals key patterns and relationships that address the main research questions and hypotheses. A recurring theme across studies is the enhanced efficiency and streamlined workflows resulting from digital tools like Building Information Modeling (BIM) and Internet of Things (IoT). Collinge (2025) documented the efficiencies achieved using social practice theory in construction projects, which align with other studies showing improved communication and reduced friction when digital tools are integrated.

Another key finding is the significant role of leadership and governance in the success of digital transformation. Ozpinar and Soofastaei (2025) emphasize that effective project management and strategic

leadership are essential for successfully integrating digital and operational technology. Similar findings are seen in studies on innovation diffusion (Daskevic & Burinskienė, 2025), where leadership and governance are critical for overcoming barriers and fostering digital innovation.

The synthesis also highlights challenges in digital integration, such as misalignment between traditional practices and digital innovation. Many studies suggest that digital transformation requires not only technological adoption but also cultural and organizational shifts. This theme is reflected in studies comparing traditional project management to digital project management (Collinge, 2025).

Quantitative findings further support these trends, showing that digital tools reduce project delays and cost overruns. This aligns with qualitative findings and supports the hypothesis that digital transformation improves project efficiency when managed through adaptive project management strategies.

Overall, the synthesis provides a nuanced view of digital transformation in construction management, emphasizing the importance of digital tools, adaptive governance, and their measurable impact on project performance. Studies such as Chen et al. (2025) and Ozpinar and Soofastaei (2025) contribute to this understanding by highlighting the role of leadership, the integration of digital tools, and the need for a systematic approach in transforming project management practices.

Additionally, the practical framework by Ozpinar and Soofastaei (2025) demonstrates how the convergence of information technology and operational technology can improve project outcomes. Collinge (2025) reinforces this by applying social practice theory, showing that collective practices and stakeholder engagement are key to driving innovation in construction.

However, the analysis also highlights methodological limitations. For instance, the reliance on qualitative data in systematic reviews may introduce subjectivity in interpreting themes. The contextual factors such as organizational culture and regulatory environments may limit the generalizability of some findings, as noted in the studies by Chen et al. (2025) and Collinge (2025). The framework proposed by Ozpinar and Soofastaei (2025) may also not account for variations in infrastructure contexts, particularly in smaller or emerging markets.

Moreover, studies like Daskevic and Burinskienė (2025) show that structured project management methodologies can help mitigate the challenges associated with digital transformation. Their mixed-methods approach highlights barriers such as technological complexity and misaligned governance, providing practical solutions to address these challenges.

In conclusion, the synthesized findings suggest that successful digital transformation in construction management requires the integration of technology, human factors, and strategic governance. While the positive outcomes point to improvements in project efficiency, further research is needed to expand sample diversity and include more quantitative metrics to evaluate the impact of digital transformation on construction management practices.

10. Conclusion and Recommendations

The review of digital transformation in construction management highlights a significant shift that impacts traditional project management practices. Studies show that digital tools such as Building Information Modeling (BIM), Internet of Things (IoT), and advanced data analytics improve project efficiency and sustainability. For example, Chen, Martins, Zhang, and Dong (2025) identify themes like sociotechnical integration, governance, and leadership as essential for successful digital transformation. Collinge (2025) emphasizes the role of social practice insights in aligning stakeholder expectations and facilitating digital innovation in construction projects. Daskevic and Burinskienė (2025) provide evidence that structured innovation diffusion and tailored project management frameworks help overcome challenges during digital implementation. Additionally, studies like Nyqvist et al. (2025) point to ongoing resistance, such as fragmented systems and lack of client demand, which require targeted managerial actions. Research by Shang et al. (2025) suggests that adopting an integrated ecosystem model can improve project execution and value sharing among stakeholders. These findings highlight that while digital transformation offers great potential, its success depends on adjusting project management practices to incorporate both technological advancements and human-centric governance.

Based on the reviewed literature, several recommendations emerge for both researchers and practitioners. Future research should focus on developing comprehensive frameworks that combine digital tools with traditional project management methods, building on frameworks proposed by Chen et al. (2025) and Ozpinar and Soofastaei (2025) to assess the impacts on project timelines, costs, and sustainability. Practitioners should adopt flexible project management approaches that integrate technology and involve active stakeholder engagement, as suggested by Collinge (2025). A collaborative culture, supported by design thinking and agile methodologies, can help overcome the challenges of digital transitions. Training and capacity building are crucial to equip project managers with the necessary digital and leadership skills. Future studies should also explore how external factors, like regulatory environments and industry challenges, affect digital transformation, as seen in the work of Daskevic and Burinskienė (2025). Lastly, longitudinal case studies and empirical research are needed to validate proposed models and frameworks, considering not only technology adoption but also the cultural and

organizational changes required for long-term success. The synthesis confirms that digital transformation in construction management is not just about adopting new tools but about fundamentally reshaping practices to foster integrated, sustainable value creation. This shift will enhance operational efficiency, stimulate innovation, and transform the way construction projects are conceptualized, executed, and evaluated.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: Mohd Dhiya Hafreez bin Kamil;* ***data collection****: Mohd Dhiya Hafreez bin Kamil;* ***analysis and interpretation of results****: Mohd Dhiya Hafreez bin Kamil;* ***draft manuscript preparation:*** *Mohd Dhiya Hafreez bin Kamil. All authors (Mohd Dhiya Hafreez bin Kamil, Mohd Najib Abd Rashid, and Mohamed Rizal Mohamed) reviewed the results and approved the final version of the manuscript.*

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