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Developing a theory of collaboration in construction based on its characteristics and indicators

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Abstract

Purpose – The significance of collaboration is continuously increasing alongside the growing complexity and interdependency in construction projects. In this regard, collaboration is regarded as a crucial element for success in construction projects, especially complex ones. Therefore, collaboration has become a significant research topic in recent years. Despite this increasing interest, our understanding of collaboration in construction is primarily limited to practical aspects, including processes, professional roles, delivery models and procurement structures. Consequently, there is a noticeable lack of a theoretical foundation for collaboration within this domain. To address this gap, this study aims to explore characteristics of collaboration in construction, identify indicators of those characteristics and then use both of them as a basis for developing a theory of collaboration in construction.

Design/methodology/approach – A systematic literature review was conducted, followed by content and thematic analysis of extracted data. The results of the content analysis were further analyzed using an abductive approach to develop the theory.

Findings – The study presents a theory of collaboration in construction that answers six core questions (what, why, how, when, where and who) expected of a theory. Additionally, it reveals characteristics of collaboration and its indicators.

Originality/value – This study enhances theoretical understanding of collaboration in construction by providing a structured foundation for future research and practical applications. The findings could aid efforts to establish a basis for measuring and improving collaboration within the industry.

Keywords Theory of collaboration in construction, Collaborative project delivery, Construction projects, Collaboration in construction projects, Construction project management, Collaboration characteristics

Paper type Research article

Introduction

Construction projects serve as crucial drivers of societal and economic development, influencing industries, communities, and overall economic growth. Effective collaboration has become essential for ensuring the success of these projects as their complexity grows (Deep *et al.*, 2021; Engebø *et al.*, 2020; Han *et al.*, 2018). Over the past decades, innovative strategies have emerged to enhance teamwork, streamline communication, and improve project results (Pe-Mora *et al.*, 2001).

Construction projects are not just technical endeavors; they are fundamentally human-centered (Deep *et al.*, 2021). They are conceived, executed, and ultimately utilized by people.

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Individuals play various roles throughout the project life cycle, contributing to both the development and the operation of these projects. The essence of a construction project is shaped by its connections to people, making human relationships a crucial aspect of project success (Deep *et al.*, 2021; Engebø *et al.*, 2020; Mollaoglu *et al.*, 2021).

The key role of people in construction projects and their interdependency, both individually and organizationally, underscores the importance of collaboration. In its simplest form, collaboration is usually understood as working together (Daget and Zhang, 2023). Hence, collaboration is seen as an essential element for project success, given the diverse range of stakeholders involved (e.g. owners, contractors, and designers). However, insufficient collaboration can lead to misaligned goals, ineffective communication, and inefficiencies. To address these challenges, the construction industry has introduced collaborative project delivery models, such as alliance and lean project delivery, which have received positive feedback (Moradi *et al.*, 2024a). While Collaboration is critical, its level and effectiveness can vary significantly across projects and stakeholders.

Despite the growing emphasis on collaboration in construction, much of the current discourse and frameworks continue to be practice-oriented (Moradi *et al.*, 2024b). They primarily focus on processes, professional roles, and procurement models. Nevertheless, a solid theoretical foundation for collaboration in this field is still lacking. This research aims to bridge this gap by identifying and conceptualizing the essential components of collaboration. This will enhance the overall theoretical understanding of collaborative dynamics in construction projects.

The absence of a dedicated collaboration theory has resulted in vague definitions of collaboration. These definitions often overlap with related concepts such as cooperation and coordination (Moradi and Klakegg, 2024a, b; Nwajei *et al.*, 2022). Consequently, the distinct characteristics of collaboration. The roles within collaborative construction approaches and the levels of collaboration remain unclear in construction management. This theoretical ambiguity hinders the development of structured methods. It also impedes assessment methodologies designed to enhance collaboration in the field. This study aims to establish a comprehensive and precise theory of collaboration in construction. To achieve this, the study aims to answer the following questions:

- *RQ1.* What are the characteristics of collaboration in construction?
- *RQ2.* What are the indicators of collaboration characteristics in construction?
- *RQ3.* What is the theory of collaboration in construction?

This article is structured into four sections. The first section provides the theoretical background, followed by the methodology presentation in the second section. The third section presents and discusses the research findings. Finally, the paper concludes by drawing insights from the findings.

Theoretical background

Definition

Previous research has offered several definitions of collaboration (e.g. Moradi and Kähkönen, 2024; Pirayesh *et al.*, 2015; Su *et al.*, 2017). While these definitions provide valuable perspectives, they vary in scope and often fail to capture the comprehensive and dynamic nature of collaboration. Meads and Ashcroft (2005) emphasized that collaboration occurs when individuals communicate and work together to achieve shared goals. Similarly, Hughes *et al.* (2012) and Himes (1995) describe collaboration as a long-term partnership between two or more organizations. This partnership aims to achieve specific business objectives by optimizing the resources of each participant. These alliances are typically founded on trust, shared goals, and a mutual understanding of expectations and values. However, these definitions still lack a fully comprehensive perspective. Collaboration is interpreted differently across disciplines, making it difficult to establish a universally accepted definition (Himes, 1995). Moreover, while collaboration can be conceptualized as both a state (reflecting the degree of collaboration at a given time) and a process (the ongoing interaction among actors), many definitions focus exclusively on one aspect. Collaboration also occurs at multiple levels, individual, team, and organizational, but many existing definitions do not adequately reflect these interconnections (Moradi and Klakegg, 2024a). A further challenge lies in the disconnect between academic and practitioner perspectives: industry professionals often conflate collaboration with cooperation and coordination, whereas academic literature tends to treat them as distinct concepts. Furthermore, while collaboration encompasses elements such as trust, communication, and shared goals, many definitions overlook critical challenges, including power imbalances and conflicting interests. Thus, despite the contributions of prior work, current definitions do not fully address the evolving, context-specific, and multidimensional nature of collaboration in construction projects (Moradi and Klakegg, 2024b).

Previous research

The recognized importance of collaboration in construction projects has led to an increasing volume of research in recent years. A holistic review of the literature reveals that prior research has concentrated on five key themes: (1) challenges and barriers to collaboration, (2) collaboration across the supply chain, (3) the relationship between collaboration and innovation, (4) enablers and success factors of collaboration, and (5) defining and understanding collaboration. The studies representing each theme are discussed in the following subsections.

Challenges and barriers in collaboration. The challenges and barriers to collaboration within the construction industry are multifaceted and deeply rooted in both industry structures and stakeholder behavior. According to Oraee *et al.* (2022), the lack of a unified approach to collaboration, such as through BIM-based construction. This is exacerbated by an overemphasis on technology, often at the expense of recognizing the critical role of people and their interactions. This issue is further compounded by unclear contractual arrangements, liability concerns, disputes over intellectual property, and data ownership challenges. All of these undermine team members' willingness to collaborate (Oraee *et al.*, 2022). Moreover, stakeholders frequently lack a shared vision and mutual trust, which inhibits open communication and the effective transfer of knowledge. Resistance to change from traditional working methods presents another significant barrier. Communication problems and incompatible organizational cultures further complicate collaboration efforts, collectively creating substantial obstacles to adopting more collaborative practices (Yap and Lim, 2023). Emuze and Smallwood (2014) note that the industry's emphasis on short-term goals and a price-oriented approach also hinders collaboration, particularly when coupled with inadequate mechanisms for problem-solving among project partners. Given the central role of contracts in the construction sector, af Hällström *et al.* (2024) highlight the complex interplay between formal contractual frameworks and informal relationships. They argue that prioritizing one over the other may disrupt the balance necessary for successful collaboration, potentially resulting in failures or stalemates. Finally, Nwajei *et al.* (2022) point out that a lack of alignment between project strategies, functions, and tools can render even well-designed collaborative systems ineffective.

Collaboration across the supply chain. Studies within this theme have examined the relationship between collaboration and supply chain performance in the construction industry. Meng (2013) observed that the industry has gradually shifted away from traditional adversarial relationships towards more collaborative supply chain models. Supply chain integration and collaboration are increasingly recognized as strategies for enhancing performance by fostering relationships and aligning activities between upstream and downstream actors. This alignment aims to improve the efficiency and quality of production processes (Koolwijk *et al.*, 2018). Savolainen *et al.* (2018) found that collaborative practices can significantly enhance productivity and quality within construction projects. Nevertheless, the construction supply chain is still considered deficient due to persistent collaboration gaps (Ali Shaikh *et al.*, 2020; Faris *et al.*, 2024).

Collaboration and innovation. The combined forces of innovation and collaboration are key drivers of progress in the construction sector. Collaboration enables the effective development and implementation of innovations, while innovation creates new opportunities for collaborative endeavors. According to Han *et al.* (2018), innovation is essential for executing complex projects, which require the integration of expertise from all involved parties and intense collaboration within networks.

Furthermore, collaborative innovation efforts and the use of Building Information Modeling (BIM) are recognized as critical for enhancing innovation capacity in the construction supply chain (Qiao *et al.*, 2021; Tang *et al.*, 2018; Zhan *et al.*, 2023). Cheng *et al.* (2023) argue that knowledge exchange, enhanced through the application of BIM, enables project participants to access valuable information resources, thereby improving competitive advantage. In addition, inter-organizational collaboration is vital for innovation in sustainable construction, as the project network increasingly replaces rigid organizational structures with more dynamic, systemic forms (Zhang *et al.*, 2020b; Zhao *et al.*, 2015). By improving processes, involving stakeholders, and leveraging digital technologies, collaboration contributes to better project management. It also streamlines information flow, reduced transaction time, greater transparency, delivers faster, and results in lower costs; all of which support innovation (Merschbrock and Munkvold, 2015).

Collaboration enablers and success factors. A variety of factors influence the success of collaboration in the construction industry. According to Deep *et al.* (2021), trust, commitment, and reliability are essential enablers of collaboration in construction projects. Prioritizing these elements in project execution decisions can significantly enhance both collaboration and overall productivity. Knowledge exchange also plays a central role in collaborative efforts, facilitating performance assessment and continuous improvement (Staykova and Underwood, 2017). In addition, team integration is a critical enabler, particularly for the implementation of joint risk management strategies. This includes practices such as stakeholder engagement, alignment of goals, team-building activities, and contractual flexibility. These outcomes can be achieved through the diffusion of collaborative values at both strategic and operational levels (Marinelli and Salopek, 2020; Mollaoglu *et al.*, 2021). Daget and Zhang (2023) found that strong collaboration among contractors, designers, and manufacturers contributes positively to efficiency in industrialized construction projects. Furthermore, effective collaboration supports the creation of mutually beneficial relationships (Faris *et al.*, 2022), enables joint rule-setting, and facilitates seamless cooperation among geographically dispersed project teams (Chowdhury *et al.*, 2021). Finally, Patel *et al.* (2012) and Pe-Mora *et al.*, 2001 propose seven categories of factors that must be considered to enhance collaborative design and engineering activities. These include: context, support mechanisms, tasks, interaction processes, team dynamics, individual characteristics, and overarching environmental factors.

Defining and understanding collaboration. Despite the availability of numerous definitions, some researchers argue that these definitions are either inadequate or inapplicable to the complex realities of construction projects. Prior research highlights both the lack of a clear, unified definition and the broad diversity of interpretations surrounding the concept of collaboration (Gomes and Tzortzopoulos, 2020). Gomes and Tzortzopoulos (2020) note that the term “collaboration” is widely used but often remains conceptually vague and formless. Hughes *et al.* (2012) found that collaboration is frequently used as an umbrella term encompassing partnering, alliancing, and joint ventures. Each of these is more specifically defined, yet a comprehensive and structured delineation of collaboration itself is often missing. Understanding these nuances is critical, as the success of collaboration frequently depends on acknowledging its different interpretations. A clear and shared definition supports better project outcomes by facilitating the transfer of best practices and reducing ambiguity. Conversely, a lack of clarity may lead to misunderstandings that hinder effective teamwork and compromise project success (London and Pablo, 2017; Ren *et al.*, 2013).

Methodology

Research design

This study employed a Grounded Theory (GT) strategy with an abductive approach to construct a theory of collaboration in construction. GT facilitates an iterative, data-driven process, allowing theory to emerge from empirical observations. Abduction, on the other hand, refines theoretical insights by integrating empirical findings with existing literature (Saunders *et al.*, 2019). By combining Grounded Theory with an abductive approach, the study ensures that theory development is not limited by preconceived notions. This allows insights to arise from the data and refines these insights as new data is collected and analyzed (Saunders *et al.*, 2019).

The study follows three key phases:

(1) A Systematic Literature Review (SLR) to synthesize prior research, identify knowledge gaps, and establish a conceptual foundation through thematic and content analysis;

(2) Complementary analysis and theory development, where GT principles guide further analysis of data without predefined assumptions, while abduction iteratively refines emerging insights to reach a specific theory; and

(3) Theory validation using the 5W1H framework, systematically assessing key aspects of collaboration (who, what, when, where, why, and how) to ensure the theory's internal consistency, relevance, and applicability. This structured, iterative process results in a comprehensive and methodologically robust theory. Figure 1 illustrates the overall research process.

Systematic literature review

A systematic literature review is a structured and comprehensive method for critically analyzing existing knowledge about a specific research question or topic (Saunders *et al.*,

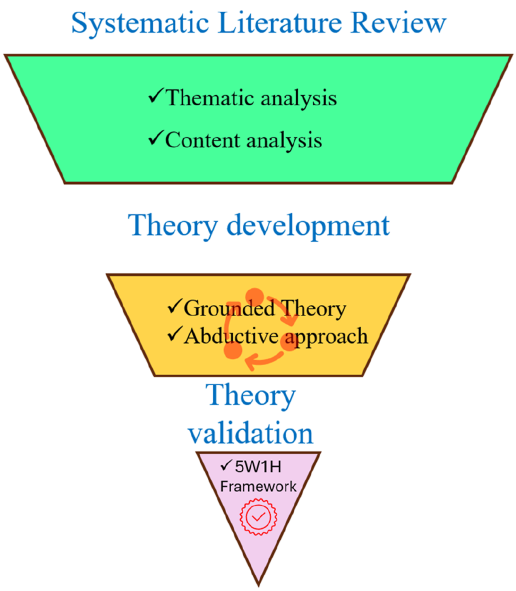

Figure 1. Research process (Authors' own work)

2019). It is essential for advancing theory by identifying established theoretical frameworks, revealing gaps, and shaping research design (Saunders *et al.*, 2019). This study employs this method to answer its questions. The conducted SLR was performed in three steps: Search protocol development, search results and screening, and analysis. This structured approach ensures that all relevant studies are systematically identified and analyzed, thereby contributing to the comprehensive development of collaboration theory. Figure 2 illustrates the overall SLR process.

Search protocol development. The search for relevant studies was completed in September 2024. Seven keywords were used in the search, including variations of "Collaboration" (see Appendix A for the complete list). Scopus was selected as the search database because it is a comprehensive source that indexes a wide range of highly regarded journals in construction management. The search was limited to studies published in English. Appendix contains the complete list of keywords, detailed search queries, and the number of results retrieved from each search.

Search results and screening. Appendix A shows that the search strategy employed a variety of filters, as shown in the advanced query column. The search was conducted without a specified time frame to ensure a comprehensive collection of the identified studies. This search resulted in the identification of 163 studies. Subsequently, the abstracts and full texts of these 163 studies were reviewed, and 58 studies were determined to be out of scope due to repetition and/or irrelevant content to collaboration in construction. The purposive approach to locating relevant studies was complemented by a snowball sampling method. Through this, a supplementary search was performed by meticulously examining the content and references of key articles to guarantee a thorough review of the pertinent literature. This in-depth analysis helps uncover and include relevant studies directly related to the core themes and findings, thereby enhancing the breadth and depth of the analysis.

Analysis. The extracted data from the relevant studies were analyzed through thematic and content analysis methods to identify key themes in collaboration research. Thematic analysis began with coding the extracted research data (i.e. findings from the reviewed studies). The coding process was data-driven, allowing concepts to emerge without imposing predefined theoretical assumptions. Conceptually relevant codes were then grouped into five overarching themes: "Challenges and barriers in Collaboration", "Collaboration across the supply chain", "Collaboration and innovation", "Collaboration enablers and success factors", and "Defining

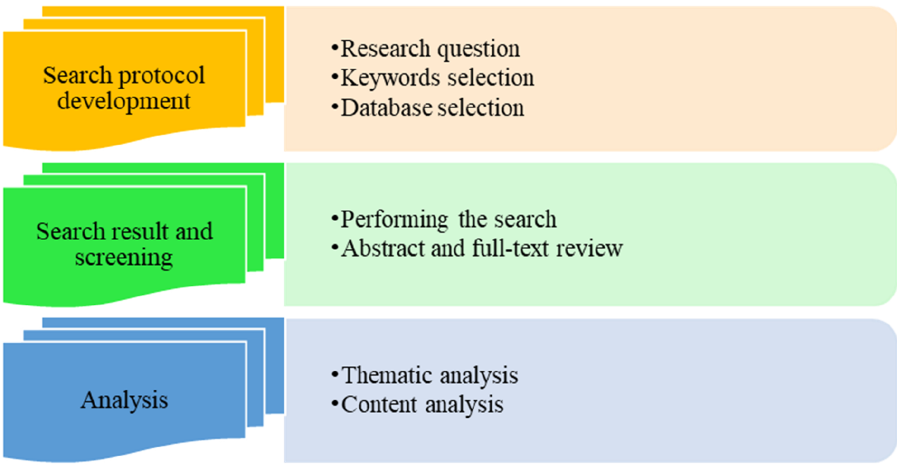

Figure 2. The process of systematic literature review (Authors' own work)

and understanding Collaboration". Among the established themes, two of them ("Defining and understanding Collaboration" and "Collaboration enablers and success factors") were found highly relevant to this study's objective and therefore, were further analyzed using content analysis. This resulted in discovering characteristics of collaboration in construction and their frequency of appearance in the literature. In addition, indicators of those characteristics were identified as the complementary result of the content analysis, providing empirical grounding for theory development. Indicators of collaboration characteristics were selected based on their emergence in the literature and their alignment with construction management practices. Only those indicators that demonstrated clear relevance to construction management were included in the framework, based on the identified characteristics. The progression from characteristics to indicators followed an abductive logic (Saunders *et al.*, 2019): recurring patterns were compared and refined concerning established conceptual frameworks in construction studies. This iterative process ensured that the indicators were both empirically grounded and theoretically coherent. The process of transforming themes into characteristics and indicators is shown in Figure 3.

The resulting indicators support theory construction and are designed to function as diagnostic tools for evaluating collaboration throughout the construction project life cycle. These indicators enable project teams to assess the level of collaboration at various stages, offering a tangible framework for real-time monitoring and improvement. By selecting indicators closely related to construction practices, the study ensures that the emerging theory is both theoretically rigorous and practically applicable.

Theory development

The study adopted a Grounded Theory strategy to develop a theory of collaboration in construction, incorporating an abductive approach to iteratively refine emerging insights. The collaboration theory was developed through an iterative process (see Figure 4), building on previous research (e.g. Moradi and Klakegg, 2024a, b) as well as characteristics and indicators that were identified in this study as a result of the conducted thematic and content analysis. This theory progressed through successive refinements, merging empirical insights with established conceptualizations. The abductive approach facilitated iterative adjustments, ensuring emerging concepts remained grounded and relevant. The iterative nature of this process enables ongoing refinement of the theory, ensuring it stays relevant and rooted in real-world practices.

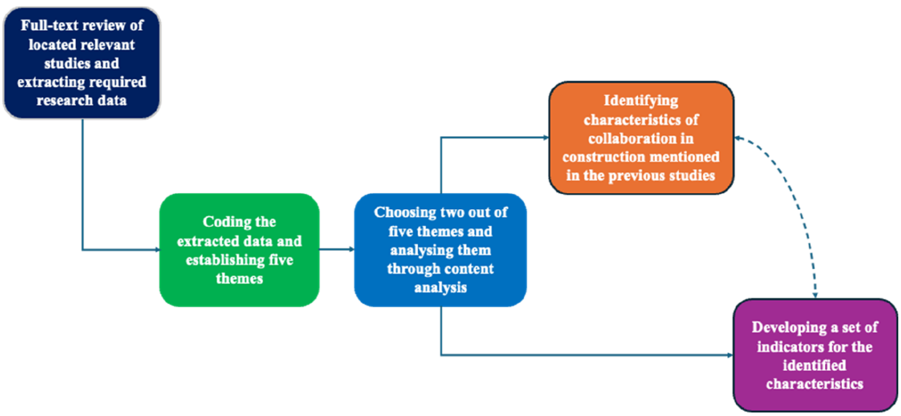

Figure 3. The process of transforming themes into characteristics and indicators (Authors' own work)

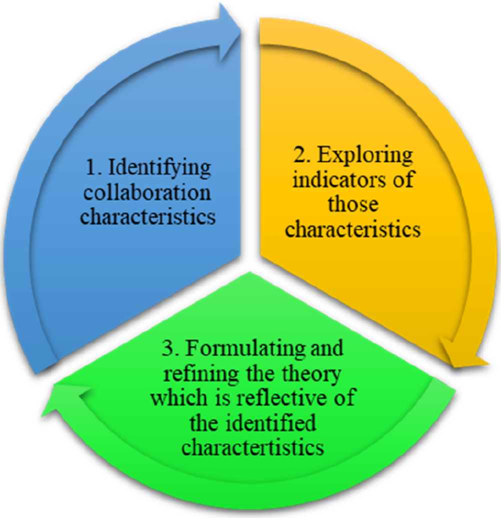

Figure 4. The process of theory development (Authors' own work)

Theory validation

After formulating the theory of collaboration in construction, the 5W1H framework (Who, What, When, Where, Why, and How) was applied to assess its completeness and relevance. This validation ensured that the definition comprehensively addressed key aspects of collaboration in construction projects. By systematically evaluating the definition against these six fundamental questions, the study ensured that the developed collaboration theory was both conceptually sound and practically applicable to construction management (Saunders *et al.*, 2019).

Results

This section presents the study's findings in three parts: (1) characteristics of collaboration, (2) Indicators of collaboration characteristics, which offer measurable aspects of these characteristics, and (3) a theory of collaboration, integrating these insights into a cohesive framework. This approach connects theoretical concepts with practical applications.

Characteristics of collaboration in construction

The content analysis identified seven key characteristics of collaboration in construction, each focusing on distinct aspects that contribute to effective teamwork. These characteristics, derived from recurring themes in prior research (e.g. Deep *et al.*, 2021; Moradi and Klakegg, 2024a, b; Yap and Lim, 2023) and their alignment with construction management practices, provide a more structured understanding of collaboration. Rather than offering a broad definition, these characteristics emphasize specific, empirically grounded elements crucial for collaborative dynamics in construction projects. Together, they establish a foundation for developing a more targeted collaboration theory. Table 1 also contains a brief explanation of each characteristic.

Indicators of collaboration characteristics

Table 2 presents 44 indicators of collaboration characteristics. These indicators are quantitative measures and observational insights, reflecting various aspects of collaboration

Table 1. The characteristics of collaboration in construction

Characteristic	Brief explanation	Reference
Common goal	Alignment on a project's desired outcomes, which ensures that all stakeholders work towards mutual outcomes (e.g. time, cost, quality, etc.)	af Hällström *et al.* (2024), Rashidian *et al.* (2024), Yap and Lim (2023), Gao *et al.* (2022), Matthews *et al.* (2018), Moradi and Sormunen (2025)
Coordination (i.e. structured facilitation)	Alignment of individual efforts and allocation of resources to reduce duplicate efforts and/or conflicting actions	Gao *et al.* (2022), Mohamad *et al.* (2014), Pe-Mora *et al.* (2001), Gao *et al.* (2022), Matthews *et al.* (2018)
Cooperation (i.e. information, knowledge and resource sharing)	Cooperation involves participants exchanging information, knowledge, and resources to facilitate mutual learning between stakeholders, reduces project life cycle redundancy, and improves the collective capacity for outcomes	Dauda *et al.* (2024), van Leeuwen and Fridqvist (2006), Lin and Wu (2021), Gao *et al.* (2022), Matthews *et al.* (2018)
Fair share of risk-reward	Equitable distribution of potential risks and benefits is essential for a positive approach, in which distribution promotes commitment to the project and encourages active participation	Bidin *et al.* (2022), Chowdhury *et al.* (2021), Nwajei *et al.* (2022), Gao *et al.* (2022), Matthews *et al.* (2018), Moradi and Sormunen (2025)
Joint problem solving	Joint problem-solving involves all stakeholders sharing their expertise and available resources to develop solutions	Meng (2013), Pablo and London (2020), Zhang *et al.* (2020), Gao *et al.* (2022), Matthews *et al.* (2018), Moradi and Sormunen (2025)
Mutual trust	The willingness of project participants to rely on and have faith in each other's capability (i.e. capacity and ability), and to share their resources and information to realize something which is mutually beneficial	Gao *et al.* (2022), Matthews *et al.* (2018), Moradi and Sormunen (2025)
Open communication	Transparent and immediate communication is essential for mutual understanding. It involves the regular exchange of information between the main stakeholders, active listening, and minimizing misunderstandings	Chen *et al.* (2022a), b, Grilo *et al.* (2013), Zhai *et al.* (2014), Gao *et al.* (2022), Matthews *et al.* (2018), Moradi and Sormunen (2025)

Source(s): Authors' own work

in construction management. While each indicator corresponds to a specific aspect of construction practices, notable commonalities highlight Collaboration's complex and multifaceted nature. To support the practical application. Table 2 also includes a brief description of each indicator, providing measurable and observable aspects that enhance the assessment of collaboration in construction projects.

Theory of collaboration in construction

This study developed a theory of collaboration in construction, building on previous definitions and conceptualizations in the literature (e.g. Han *et al.*, 2018; Moradi and Klakegg, 2024a, b), and identified characteristics and indicators in this study. The following statement presents the theory of collaboration in construction:

> Collaboration in construction projects happens when the realization of common goal(s) and mutual benefit(s) drives coordination of interdependent participants' trust-based cooperation.

Table 2. Indicators of collaboration characteristics

No.	Characteristic	Indicator	Brief description
1	Common Goal	Alignment of project aims among stakeholders (Gao *et al.*, 2022; Grilo *et al.*, 2013)	This indicator ensures that all stakeholders share a unified vision of their project
2		Alignment with broader societal or environmental goals (Antucheviciene *et al.*, 2022; Zhang *et al.*, 2020a, b)	This indicator evaluates the extent to which project objectives promote sustainability, social responsibility, and regulatory compliance
3		Clarity and measurability of the common goal (Grilo *et al.*, 2013; Zhao *et al.*, 2015)	This indicator guarantees that project objectives are clearly defined, transparent, and measurable for all stakeholders
4		Having formal documentation of shared goals (Gao *et al.*, 2022; Wang *et al.*, 2024)	This indicator assesses alignment among project stakeholders by establishing clear responsibilities and expectations
5		Periodic review and re-alignment of goals (El-Gohary and El-Diraby, 2010; Engebø *et al.*, 2020; Wang *et al.*, 2020)	This indicator ensures that project outcomes stay relevant by regularly assessing progress, monitoring the initially defined goals, and addressing challenges
6		Stakeholder engagement and commitment to goal achievement (Deep *et al.*, 2021; Zhang *et al.*, 2024)	This indicator reflects stakeholders' engagement and commitment to achieving a project's objectives
7	Fair Share of Risk-Reward	Balance between rewards and efforts among parties (Antucheviciene *et al.*, 2022; Chen *et al.*, 2022a, b)	This indicator reflects the fairness of distributing benefits (rewards) based on each stakeholder's input (efforts), ensuring mutual satisfaction and equitable collaboration
8		Equitable risk allocation across stakeholders (Chen *et al.*, 2022a, b)	This indicator pertains to the distribution of risks, with each stakeholder accountable for their management and control. It promotes fairness and balanced responsibility among project participants, encourages Collaboration, and reduces conflicts
9		Proportional risk-reward alignment with contribution (Antucheviciene *et al.*, 2022; Deep *et al.*, 2021)	This indicator assesses risk and reward allocation based on each stakeholder's contributions. Based on formal project documents, it ensures that higher contributors assume and gain appropriate levels of risk and reward
10		Stakeholder satisfaction with risk-reward mechanisms (Deep *et al.*, 2021; Marinelli and Salopek, 2020)	This indicator assesses how well the risk-reward balance meets stakeholder expectations, ensuring fair risk allocation, appropriate rewards, and collaboration for project success
11		Transparent financial incentives and penalties (Antucheviciene *et al.*, 2022; Bresnen and Marshall, 2000; Challender, 2017)	This indicator ensures measurable rewards and penalties based on performance, promotes accountability, and encourages parties to achieve project goals while minimizing risks from unclear expectations

(*continued*)

Table 2. Continued

No.	Characteristic	Indicator	Brief description
12		Use of collaborative risk management frameworks (Marinelli and Salopek, 2020; Mollaoglu *et al.*, 2021)	This indicator relates to collaborative stakeholder strategies for identifying, assessing, monitoring, and mitigating risks
13	Information, Knowledge, and Resource Sharing	Accessibility of shared information repositories (Cheng *et al.*, 2023; Matthews *et al.*, 2018)	This indicator refers to how easily project team members can access information about the project, shared platforms or databases, pertinent project knowledge, and the necessary resources (e.g. material, human resources, etc.)
14		Data security and privacy in shared platforms (El-Gohary and El-Diraby, 2010; Patel *et al.*, 2012)	This indicator refers to how easily project team members can access information about the project, shared platforms or databases, relevant project knowledge, and more
15		Frequency of knowledge-sharing workshops or meetings (Marinelli and Salopek, 2020; Staykova and Underwood, 2017)	This indicator measures the frequency of knowledge-sharing workshops and stakeholder meetings, reflecting collaboration levels
16		Knowledge retention mechanisms (Patel *et al.*, 2012; Sattar *et al.*, 2021)	This indicator refers to strategies for capturing, storing, refining, and reusing valuable project knowledge
17		Perceived value of shared resources among stakeholders (Antucheviciene *et al.*, 2022; Patel *et al.*, 2012)	This indicator shows how stakeholders evaluate the benefits of shared information, knowledge, and resources, which affects collaboration, efficiency, decision-making, and overall project success
18		Timeliness and relevance of shared information (Haghsheno *et al.*, 2020; Staykova and Underwood, 2017)	This indicator ensures that stakeholders obtain accurate, timely data when needed, reducing delays and enhancing the overall project
19		Use of collaborative tools and platforms (Chowdhury *et al.*, 2021; Li *et al.*, 2022)	This indicator pertains to digital systems that enable real-time communication, document and information sharing/ exchange, and data integration, which enhances teamwork, decision-making, and efficiency in managing construction projects
20	Joint Problem Solving	Documented lessons learned and improvements (Sattar *et al.*, 2021; Staykova and Underwood, 2017)	This indicator reliably records project challenges, solutions, issue logs, and enhancements to promote continuous improvement, knowledge sharing, and more effective future collaboration
21		Effectiveness of solutions derived from collaboration (Deep *et al.*, 2021; Fulford and Standing, 2014)	This indicator evaluates how collaborative problem-solving produces tangible outcomes that enhance processes, minimize risks, and elevate the overall quality of team performance
22		Frequency of joint problem-solving sessions (Staykova and Underwood, 2017; Zhang *et al.*, 2020a, b)	This indicator shows the frequency of collaboration among project teams and key stakeholders to address challenges, fostering shared accountability and enhancements in complex construction projects

(*continued*)

Table 2. Continued

No.	Characteristic	Indicator	Brief description
23		Participation of relevant stakeholders in problem-solving (Mollaoglu *et al.*, 2021; Staykova and Underwood, 2017; Zhang *et al.*, 2024)	The indicator measures stakeholder involvement in solving problems, ensuring project challenges are addressed through Collaboration, clear communication, and innovative solutions in complex construction projects
24		Speed of conflict resolution (Mollaoglu *et al.*, 2021; Pe-Mora *et al.*, 2001)	This indicator measures how quickly project teams resolve disputes together. It reflects effective joint problem-solving that minimizes delays, reduces costs, controls quality, and ensures smooth, coordinated project execution
25		Use of advanced problem-solving frameworks (Sattar *et al.*, 2021; Wang *et al.*, 2023)	This indicator reflects a commitment to collaborative decision-making and analysis. Teams use innovative methods to diagnose issues, identify solutions, and optimize project outcomes
26	Mutual Trust	Absence of major disputes or litigations (Bresnen and Marshall, 2000; Mollaoglu *et al.*, 2021)	This indicator evaluates conflicts among stakeholders. A lack of issues signifies strong collaboration, clear communication, and effective conflict resolution, fostering a stable work environment
27		Adherence to agreed timelines and commitments (Antucheviciene *et al.*, 2022; Deep *et al.*, 2021)	This indicator tracks adherence to timelines, fostering trust among stakeholders and encouraging progress
28		Consistency in stakeholder actions over time (Daget and Zhang, 2023; Deep *et al.*, 2021; Kapogiannis and Sherratt, 2018)	This indicator shows that stakeholders follow established practices and agreements consistently over time
29		History of positive interactions among parties (Bresnen and Marshall, 2000; Patel *et al.*, 2012)	This indicator assesses successful collaborations and conflict resolution, fostering trust among stakeholders
30		Stakeholder perceptions of honesty and integrity (Haghsheno *et al.*, 2020; Patel *et al.*, 2012)	This indicator supports mutual trust by ensuring dependable commitments, promoting cooperation, and reducing conflicts during project execution
31		Transparency in decision-making (Haghsheno *et al.*, 2020; Staykova and Underwood, 2017)	This indicator tracks accountability, manages stakeholder engagement, and documents misunderstandings in the project
32	Open Communication	Active listening and conflict resolution (Antucheviciene *et al.*, 2022; Connaughton and Collinge, 2021; Zhang *et al.*, 2024)	This indicator assesses team engagement, empathy, open communication, feedback, understanding of each other's perspectives, and issue resolutions to achieve effective project coordination and construction management goals
33		Availability of communication tools and technology (El-Gohary and El-Diraby, 2010; Fulford and Standing, 2014)	This indicator measures access to modern digital platforms and hardware in construction projects
34		Clarity of communication channels (Moradi *et al.*, 2024a, b; Staykova and Underwood, 2017; Zhang *et al.*, 2024)	This indicator is measured by assessing protocols, response times, and designated roles

(*continued*)

Table 2. Continued

No.	Characteristic	Indicator	Brief description
35		Conflict avoidance mechanisms in communication (Haghsheno *et al.*, 2020; Staykova and Underwood, 2017)	This indicator includes measurable guidelines, feedback, and defined escalation paths that enable early issue detection and resolution, enhancing transparency and project success
36		Cultural sensitivity in communication (Patel *et al.*, 2012; Sattar *et al.*, 2021; Zhang *et al.*, 2024)	This indicator enhances clarity, reduces misunderstandings, and fosters collaboration via surveys, conflict resolution, and stakeholder feedback
37		Effectiveness of feedback mechanisms (Bresnen and Marshall, 2000; Mollaoglu *et al.*, 2021; Sattar *et al.*, 2021; Staykova and Underwood, 2017)	This indicator measures effective feedback that enhances collaboration, reduces errors, and improves project outcomes through response time, clarity, actionability, and implementation rate
38		Frequency of communication among stakeholders (Daget and Zhang, 2023; Patel *et al.*, 2012; Staykova and Underwood, 2017)	This indicator tracks the frequency of communication among stakeholders, which measures how often project participants exchange information
39		Stakeholder satisfaction with communication quality (Bresnen and Marshall, 2000; Greenwood and Wu, 2012)	This indicator monitors how well project communication meets stakeholder expectations in clarity, timeliness, and transparency
40	Structured Facilitation	Defined protocols for decision-making (Chen *et al.*, 2022a, b; Patel *et al.*, 2012)	This indicator refers to established procedures that guide decisions, ensuring clarity, accountability, and efficiency
41		Effectiveness of facilitation in achieving milestones (Bresnen and Marshall, 2000)	This indicator evaluates prompt decision-making, issue resolution, and alignment among stakeholders. It is typically quantified by milestone completion rates, adherence to schedules, and a reduction in rework
42		The presence of a dedicated project facilitator (Abdirad and Pishdad-Bozorgi, 2014; Freytag and Storvang, 2016; Mollaoglu *et al.*, 2021)	This indicator monitors whether a designated individual actively facilitates collaboration, maintains structured coordination, and resolves conflict in a construction project
43		Regular structured meetings (af Hällström *et al.*, 2021; Merschbrock and Munkvold, 2015; Staykova and Underwood, 2017; Zhao *et al.*, 2015)	This indicator refers to planned, organized meetings that ensure consistent communication, decision-making, and problem-solving among project stakeholders
44		Use of facilitation tools and techniques (El-Gohary and El-Diraby, 2010; Haghsheno *et al.*, 2020; Matthews *et al.*, 2018)	This indicator measures the use of methods like workshops and brainstorming to boost collaboration, problem-solving, decision-making, and team coordination

Source(s): Authors' own work

In further details, this theory explains collaboration in construction projects as a phenomenon in which interdependent stakeholders work together with mutual trust, open communication, and a fair share of risk-reward to jointly solve-problems and realize common goals through information, knowledge, and resource sharing (i.e. cooperation), which is enabled by structured facilitation (i.e. coordination). This theory posits that collaboration in construction is a multifaceted process defined by several dimensions. These dimensions are discussed here through the lens of six questions (see Table 3), which every theory is expected to answer as an

Table 3. Theory validation

Questions	Answer
What?	A process involving mutual trust, open communication, and shared risk-reward aimed at solving problems and achieving common goals
Why?	To jointly solve problems and realize common goals
How?	Through cooperation (information, knowledge, and resource sharing) and coordination (structured facilitation) effective collaboration can be enabled
When?	Need to solve complex problems, leverage shared resources, or achieve objectives
Where?	Occurs in contexts where interdependent stakeholders converge
Who?	Interdependent stakeholders in construction projects

Source(s): Authors' own work

indication of its validity. The process (What) involves establishing a foundation of mutual trust, open communication, and fair risk-reward sharing that supports effective problem-solving and goal attainment. The underlying purpose (Why) is to enable stakeholders to collectively overcome challenges and achieve shared objectives. The means (How) are realized through cooperation, via the exchange of information, knowledge, and resources, and coordination through structured facilitation of interdependent stakeholders' joint efforts. The theory further specifies that this collaborative process becomes particularly vital when complex problems arise, or shared resources must be leveraged (When); in environments where interdependent stakeholders converge (Where); and is driven by these very stakeholders (Who). Collectively, these dimensions form a robust theory that systematically addresses the essential questions concerning collaboration in construction.

Finally, Figure 5 provides a visual representation of the developed theory of collaboration in construction.

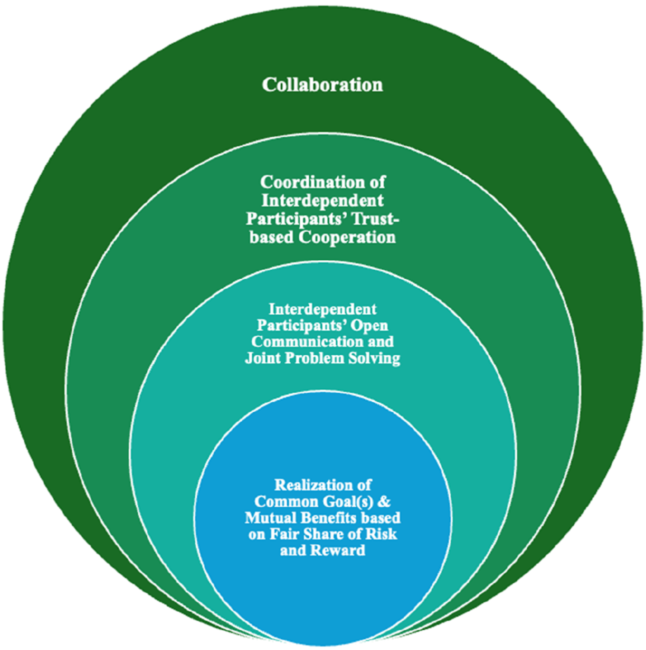

Figure 5. A visual representation of the theory of collaboration in construction (Authors' own work)

Discussion

Wrap-up of findings

This study explored the nature of collaboration in construction through a structured methodology that includes a Systematic Literature Review (SLR), thematic and content analysis, Grounded Theory, and abductive reasoning. The findings were organized into three interrelated groups: the characteristics of collaboration in construction, the indicators of those characteristics, and the resultant theory (Deep *et al.*, 2021; Han *et al.*, 2018; Moradi and Klakegg, 2024a, b; Yap and Lim, 2023).

The seven core characteristics of collaboration, mutual trust, open communication, shared risk and reward, joint problem-solving, common goals, cooperation, and coordination, offer a refined and structured lens for understanding and evaluating collaboration in the construction industry. While prior research acknowledges these elements in relation to collaborative project delivery models (e.g. alliance, partnering, lean project delivery), this study advances the field by clearly distinguishing them as separate traits and establishing their measurability. Each factor is treated as an independent yet interconnected aspect of collaborative performance. In addition, this study emphasizes collaboration as a managerial and relational process applicable to various collaborative or traditional project delivery models. It examines the key characteristics and indicators that define collaboration, irrespective of the contractual framework employed. This distinction clarifies that our theory can be applied across different project settings, offering a broader and more transferable foundation for understanding and evaluating collaboration in construction.

A theory must be measurable to support testing, objective application, cross-context comparison, and practical implementation. By operationalizing collaboration through 44 carefully developed indicators, this study provides a more granular understanding of each characteristic. These indicators function not only as analytical tools but also as a bridge between the theory's core components and the qualitative research approach. Furthermore, they serve as practical diagnostic instruments, enabling project teams to monitor the level of collaboration throughout the project life cycle.

In practice, these indicators can be applied through structured surveys, expert scoring, case studies, or analysis of project documents. They can also aid in developing performance metrics for benchmarking collaboration across different projects or organizations. Future empirical research should test these tools in real-world contexts to assess their usability. In contrast to broader qualitative models, this theory presents a structured, testable framework for real-world application.

A significant contribution of this study lies in addressing the longstanding lack of a unified definition of collaboration theory within the construction sector. The term is often conflated with cooperation or coordination, leading to conceptual ambiguity and inconsistent implementation. This theory resolves that issue by offering a clear and empirically grounded definition of collaboration, articulated through seven core characteristics and their supporting indicators. As such, it provides a shared vocabulary for industry professionals and transforms collaboration from a vague notion into a manageable, assessable, and actionable process, ultimately enhancing stakeholder alignment and improving project outcomes.

Despite the contributions of this research, several limitations remain. The systematic literature review (SLR) utilized a certain number of keywords and Scopus as the database for locating relevant studies. It also restricted the language of research to English. These factors may have limited the identification of additional relevant studies. Additionally, while the 5W1H framework has internally validated the theory, further empirical testing, such as case studies or expert interviews, is required to confirm its external validity across various construction contexts. Future research should further refine the theory and evaluate its relevance across different types of construction projects, regulatory contexts, and collaboration measurement, thereby increasing its generalizability and enhancing its practical impact.

Implications for theory

This study advances the theoretical development of collaboration in construction by providing a structured and comprehensive model based on empirical findings. Utilizing the 5W1H framework, the study defines collaboration through seven core characteristics and supports them with 44 measurable indicators. This integrated approach transcends broad definitions, offering a concrete, testable foundation for future research. The close relationship between characteristics and indicators enhances the theory's practical relevance and equips researchers with tools to measure collaboration in empirical studies. Consequently, the proposed framework bridges the gap between theory and practice, facilitating more accurate evaluation and modeling of collaborative behavior in construction projects.

Implications for practice

This research has practical implications for real-world construction projects. The developed theory of collaboration, along with its characteristics and indicators, empowers project managers to better understand and manage stakeholders' collaboration. This enables the identification of areas that require improvement. Furthermore, the results of this study provide a solid foundation for developing a methodology to measure and enhance the level of collaboration in construction projects.

Conclusions

This study discovered characteristics of collaboration in construction and their associated indicators, based on which a theory was developed. Accordingly, the main conclusions of this study regarding collaboration in construction projects are as follows:

(1) Collaboration in construction happens when the realization of common goal(s) and mutual benefit(s) drives coordination of interdependent participants' trust-based cooperation.

(2) Without common goal(s), mutual benefit(s), and transparency, it is very unlikely to be able to start and continue a constructive collaboration.

(3) Cooperation and coordination are two main components of collaboration.

(4) The core characteristics of collaboration include a common goal, fair distribution of risk and reward, joint problem-solving, cooperation through the sharing of information, knowledge, and resources, mutual trust, open communication, and structured facilitation (coordination).

This research contributes to both theory and practice in construction management by exploring characteristics of collaboration and indicators of those characteristics and developing a theory of collaboration in construction accordingly. However, the literature review was limited by selecting specific keywords and databases, which may have reduced the range of sources consulted. Therefore, readers should consider these limitations when assessing the study's scope and the generalizability of its findings.

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This study did not involve any human participants or animals. No AI-based tools were used for drafting, summarizing, or refining this manuscript.

Appendix

Table A1. Keywords, search queries, and search results

Keywords	Database	Advanced query	No. Articles	Out of scope
Collaboration in construction	Scopus	TITLE (Collaboration AND in AND construction) AND (LIMIT-TO (EXACTKEYWORD, “Construction Industry”) OR LIMIT-TO (EXACTKEYWORD, “Collaboration”) OR LIMIT-TO (EXACTKEYWORD, “Project Management”) OR LIMIT-TO (EXACTKEYWORD, “Construction Projects”) OR LIMIT-TO (EXACTKEYWORD, “Construction”) OR LIMIT-TO (EXACTKEYWORD, “Construction Management”) OR LIMIT-TO (EXACTKEYWORD, “Lean Construction”)) AND (LIMIT-TO (SUBJAREA, “ENGI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (LANGUAGE, “English”))	54	16
Collaborative construction	Scopus	TITLE (collaborative AND construction) AND (LIMIT-TO (EXACTKEYWORD, “Construction Industry”) OR LIMIT-TO (EXACTKEYWORD, “Project Management”) OR LIMIT-TO (EXACTKEYWORD, “Collaborative Construction”) OR LIMIT-TO (EXACTKEYWORD, “Knowledge Management”) OR LIMIT-TO (EXACTKEYWORD, “Collaborative Learning”) OR LIMIT-TO (EXACTKEYWORD, “Collaboration”) OR LIMIT-TO (EXACTKEYWORD, “Construction”) OR LIMIT-TO (EXACTKEYWORD, “Construction Projects”) OR LIMIT-TO (EXACTKEYWORD, “Construction Management”) OR LIMIT-TO (EXACTKEYWORD, “Collaborative Management”)) AND (LIMIT-TO (SUBJAREA, “ENGI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (SRCTYPE, “j”))	102	41
Collaborative project delivery	Scopus	TITLE (collaborative AND project AND delivery) AND (LIMIT-TO (EXACTKEYWORD, “Construction Industry”) OR LIMIT-TO (EXACTKEYWORD, “Project Management”) OR LIMIT-TO (EXACTKEYWORD, “Collaborative Construction”) OR LIMIT-TO (EXACTKEYWORD, “Collaboration”) OR LIMIT-TO (EXACTKEYWORD, “Construction”) OR LIMIT-TO (EXACTKEYWORD, “Construction Projects”) OR LIMIT-TO (EXACTKEYWORD, “Construction Management”) OR LIMIT-TO (EXACTKEYWORD, “Civil Engineering”) OR LIMIT-TO (EXACTKEYWORD, “Project Delivery”) OR LIMIT-TO (EXACTKEYWORD, “Project Collaboration”)) AND (LIMIT-TO (SUBJAREA, “ENGI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (LANGUAGE, “English”))	6	0

(*continued*)

Table A1. Continued

Keywords	Database	Advanced query	No. Articles	Out of scope
Collaboration indicators	Scopus	TITLE (Collaboration AND indicators) AND (LIMIT-TO (EXACTKEYWORD, “Measurement”) OR LIMIT-TO (EXACTKEYWORD, “Cooperative Behavior”) OR LIMIT-TO (EXACTKEYWORD, “Cooperation”) OR LIMIT-TO (EXACTKEYWORD, “Collaboration”)) AND (LIMIT-TO (SUBJAREA, “ENGI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”))	1	1
Total			163	58

Source(s): Authors’ own work

References

Abdirad, H. and Pishdad-Bozorgi, P. (2014), “Developing a framework of metrics to assess collaboration in integrated project delivery”, *50th ASC Annual International Conference Proceedings*, doi: 10.1108/CI-07-2020-0123.

af Hällström, A., Bosch-Sijtsema, P., Poblete, L., Rempling, R. and Karlsson, M. (2021), “The role of social ties in collaborative project networks: a tale of two construction cases”, *Construction Management and Economics*, Vol. 39 No. 9, pp. 723-738, doi: 10.1080/01446193.2021.1949740.

af Hällström, A., Bosch-Sijtsema, P. and Poblete, L. (2024), “Challenges with collaboration: the interaction of formal and informal ties in infrastructure construction”, *Construction Management and Economics*, Vol. 43 No. 1, pp. 7-25, doi: 10.1080/01446193.2024.2371153.

Ali Shaikh, F., Shahbaz, M.S., Ud Din, S. and Odhano, N. (2020), “The role of collaboration and integration in the supply chain of construction industry”, *Civil Engineering Journal (Iran)*, Vol. 6 No. 7, pp. 1300-1313, doi: 10.28991/cej-2020-03091549.

Antucheviciene, J., Santos, P., Moradi, S., Kähkönen, K. and Sormunen, P. (2022), “Analytical and conceptual perspectives toward behavioral elements of collaborative delivery models in construction projects”, *Buildings*, Vol. 12 No. 3, p. 316, doi: 10.3390/buildings.

Bidin, Z.A., Bohari, A.A.M. and Khalil, N. (2022), “Government intervention through collaborative approach in promoting the adoption of green procurement for construction projects”, *International Journal of Sustainable Construction Engineering and Technology*, Vol. 13 No. 2, pp. 68-82, doi: 10.30880/ijscet.2022.13.02.006.

Bresnen, M. and Marshall, N. (2000), “Building partnerships: case studies of client-contractor collaboration in the UK construction industry”, *Construction Management and Economics*, Vol. 18 No. 7, pp. 819-832, doi: 10.1080/014461900433104.

Challender, J. (2017), “Trust in collaborative construction procurement strategies”, *Proceedings - Institution of Civil Engineers: Management, Procurement and Law*, Vol. 170 No. 3, pp. 115-124, doi: 10.1680/jmapl.16.00018.

Chen, G., Chen, J., Tang, Y., Li, Q. and Luo, X. (2022a), “Identifying effective collaborative behaviors in building information modeling–enabled construction projects”, *Journal of Construction Engineering and Management*, Vol. 148 No. 6, 04022026, doi: 10.1061/(asce)co.1943-7862.0002270.

Chen, G., Chen, J., Tang, Y., Ning, Y. and Li, Q. (2022b), “Collaboration strategy selection in BIM-enabled construction projects: a perspective through typical collaboration profiles”, *Engineering Construction and Architectural Management*, Vol. 29 No. 7, pp. 2689-2713, doi: 10.1108/ECAM-01-2021-0004.

Cheng, J., Huang, L., Jiang, L., Chen, J., Chen, W. and He, Y. (2023), "Fostering knowledge collaboration in construction projects: the role of BIM application", *Buildings*, Vol. 13 No. 3, p. 812, doi: 10.3390/buildings13030812.

Chowdhury, M., Hosseini, M.R., Martek, I., Edwards, D.J. and Wang, J. (2021), "The effectiveness of web-based technology platforms in facilitating construction project collaboration: a qualitative analysis of 1,152 user reviews", *Journal of Information Technology in Construction*, Vol. 26, pp. 953-973, doi: 10.36680/J.ITCON.2021.051.

Connaughton, J.N. and Collinge, W.H. (2021), "Trialling a new approach to interdisciplinary collaboration in UK construction: a projects-as-practice analysis", *Construction Management and Economics*, Vol. 39 No. 7, pp. 595-616, doi: 10.1080/01446193.2021.1933558.

Daget, Y.T. and Zhang, H. (2023), "Influence of collaborative relationships on the performance of design-construction efficiency in industrialized construction", *Journal of Civil Engineering and Management*, Vol. 29 No. 5, pp. 418-438, doi: 10.3846/jcem.2023.18868.

Dauda, J.A., Ajayi, S., Omotayo, T., Oladiran, O.O. and Ilori, O.M. (2024), "Implementation of lean for small- and medium-sized construction organisational improvement", *Smart and Sustainable Built Environment*, Vol. 13 No. 3, pp. 496-511, doi: 10.1108/SASBE-10-2022-0233.

Deep, S., Gajendran, T. and Jefferies, M. (2021), "A systematic review of 'enablers of collaboration' among the participants in construction projects", *International Journal of Construction Management*, Vol. 21 No. 9, pp. 919-931, doi: 10.1080/15623599.2019.1596624.

El-Gohary, N.M. and El-Diraby, T.E. (2010), "Dynamic knowledge-based process integration portal for collaborative construction", *American Society of Civil Engineers*, Vol. 136 No. 3, pp. 316-328, doi: 10.1061/ASCECO.1943-7862.0000147.

Emuze, F. and Smallwood, J.J. (2014), "Collaborative working in South African construction: contractors' perspectives", *Journal of Engineering, Design and Technology*, Vol. 12 No. 3, pp. 294-306, doi: 10.1108/JEDT-08-2010-0057.

Engebø, A., Lædre, O., Young, B., Larssen, P.F., Lohne, J. and Klakegg, O.J. (2020), "Collaborative project delivery methods: a scoping review", *Journal of Civil Engineering and Management*, Vol. 26 No. 3, pp. 278-303, doi: 10.3846/jcem.2020.12186.

Faris, H., Gaterell, M. and Hutchinson, D. (2022), "Investigating underlying factors of collaboration for construction projects in emerging economies using exploratory factor analysis", *International Journal of Construction Management*, Vol. 22 No. 3, pp. 514-526, doi: 10.1080/15623599.2019.1635758.

Faris, H., Gaterell, M. and Hutchinson, D. (2024), "Developing a collaborative framework for construction projects in emerging economies", *Smart and Sustainable Built Environment*, Vol. 13 No. 1, pp. 199-216, doi: 10.1108/SASBE-10-2021-0186.

Freytag, P.V. and Storvang, P. (2016), "Dynamics of a facilitator's role: insights from the Danish construction industry", *Management Revue*, Vol. 27 No. 3, pp. 117-138, doi: 10.5771/0935-9915-2016-3-117.

Fulford, R. and Standing, C. (2014), "Construction industry productivity and the potential for collaborative practice", *International Journal of Project Management*, Vol. 32 No. 2, pp. 315-326, doi: 10.1016/j.ijproman.2013.05.007.

Gao, Y., Liu, X., Zhang, S., Zhang, J. and Guo, Q. (2022), "BIM application and collaboration in construction projects: a perspective of the Chinese construction market", *Construction Management and Economics*, Vol. 40 No. 6, pp. 429-441, doi: 10.1080/01446193.2022.2080240.

Gomes, D. and Tzortzopoulos, P. (2020), "Metaphors of collaboration in construction", *Canadian Journal of Civil Engineering*, Vol. 47 No. 2, pp. 118-131, doi: 10.1139/cjce-2018-0461.

Greenwood, D. and Wu, S. (2012), "Establishing the association between collaborative working and construction project performance based on client and contractor perceptions", *Construction Management and Economics*, Vol. 30 No. 4, pp. 299-308, doi: 10.1080/01446193.2012.666801.

Grilo, A., Zutshi, A., Jardim-Goncalves, R. and Steiger-Garcao, A. (2013), "Construction collaborative networks: the case study of a building information modelling-based office building project", *International Journal of Computer Integrated Manufacturing*, Vol. 26 Nos 1-2, pp. 152-165, doi: 10.1080/0951192X.2012.681918.

Haghsheno, S., Budau, M.R.D. and Russmann, E. (2020), "Collaboration barometer – development of a tool for measuring collaboration during design and construction", *IGLC 28-28th Annual Conference of the International Group for Lean Construction 2020*, The International Group for Lean Construction, pp. 325-336, doi: 10.24928/2020/0073.

Han, Y., Li, Y., Taylor, J.E., Asce, M. and Zhong, J. (2018), "Characteristics and evolution of innovative collaboration networks in architecture, engineering, and construction: study of national prize-winning projects in China", *Journal of Construction Engineering and Management*, Vol. 144 No. 6, 04018038, doi: 10.1061/(ASCE).

Himes, P.E. (1995), "Partnering in the construction process: the method for the 1990s and beyond", *Facilities*, Vol. 13 No. 6, pp. 13-15.

Hughes, D., Williams, T. and Ren, Z. (2012), "Differing perspectives on collaboration in construction", *Construction Innovation*, Vol. 12 No. 3, pp. 355-368, doi: 10.1108/14714171211244613.

Kapogiannis, G. and Sherratt, F. (2018), "Impact of integrated collaborative technologies to form a collaborative culture in construction projects", *Built Environment Project and Asset Management*, Vol. 8 No. 1, pp. 24-38, doi: 10.1108/BEPAM-07-2017-0043.

Koolwijk, J.S.J., van Oel, C.J., Wamelink, J.W.F. and Vrijhoef, R. (2018), "Collaboration and integration in project-based supply chains in the construction industry", *Journal of Management in Engineering*, Vol. 34 No. 3, 04018001, doi: 10.1061/(asce)me.1943-5479.0000592.

Li, Y., Sun, H., Li, D., Song, J. and Ding, R. (2022), "Effects of digital technology adoption on sustainability performance in construction projects: the mediating role of stakeholder collaboration", *Journal of Management in Engineering*, Vol. 38 No. 3, 04022016, doi: 10.1061/(asce)me.1943-5479.0001040.

Lin, J.R. and Wu, D.P. (2021), "An approach to twinning and mining collaborative network of construction projects", *Automation in Construction*, Vol. 125, 103643, doi: 10.1016/j.autcon.2021.103643.

London, K. and Pablo, Z. (2017), "An actor–network theory approach to developing an expanded conceptualization of collaboration in industrialized building housing construction", *Construction Management and Economics*, Vol. 35 Nos 8-9, pp. 553-577, doi: 10.1080/01446193.2017.1339361.

Marinelli, M. and Salopek, M. (2020), "Joint risk management and collaborative ethos: exploratory research in the UK construction sector", *Journal of Engineering, Design and Technology*, Vol. 18 No. 2, pp. 343-361, doi: 10.1108/JEDT-03-2019-0071.

Matthews, J., Love, P.E.D., Mewburn, J., Stobaus, C. and Ramanayaka, C. (2018), "Building information modelling in construction: insights from collaboration and change management perspectives", *Production Planning and Control*, Vol. 29 No. 3, pp. 202-216, doi: 10.1080/09537287.2017.1407005.

Meads, G. and Ashcroft, J. (2005), *The Case for Interprofessional Collaboration*, Oxford, doi: 10.1002/9780470776308.

Meng, X. (2013), "Change in UK construction: moving toward supply chain collaboration", *Journal of Civil Engineering and Management*, Vol. 19 No. 3, pp. 422-432, doi: 10.3846/13923730.2012.760479.

Merschbrock, C. and Munkvold, B.E. (2015), "Effective digital collaboration in the construction industry - a case study of BIM deployment in a hospital construction project", *Computers in Industry*, Vol. 73, pp. 1-7, doi: 10.1016/j.compind.2015.07.003.

Mohamad, M.I., Ibrahim, R. and Nekooie, M.A. (2014), "A new method for evaluating the current collaborative teamwork environment within the Malaysian construction industry", *International Journal of Management Science and Engineering Management*, Vol. 9 No. 4, pp. 265-275, doi: 10.1080/17509653.2014.917362.

Mollaoglu, S., Sparkling, A.E., Garcia, A. and Polkinghorn, B.D. (2021), “Collaborative partnering for airport construction projects: state-of-practice”, *Journal of Management in Engineering*, Vol. 37 No. 3, 04021003, doi: 10.1061/(ASCE)ME.1943-5479.0000895.

Moradi, S. and Kähkönen, K. (2024), “Competency profile of project managers for collaborative construction”, in *Routledge Handbook of Collaboration in Construction*, 9th ed., Routledge, London, pp. 107-118, doi: 10.1201/9781003379553-12.

Moradi, S. and Klakegg, O. (2024b), “Conceptualization of collaboration, cooperation, and coordination in construction projects”, *IOP Conference Series: Earth and Environmental Science*, Vol. 1389 No. 1, 012021, doi: 10.1088/1755-1315/1389/1/012021.

Moradi, S. and Klakegg, O.J. (2024a), “Basis for collaborative practices in construction: definition of collaboration, cooperation, and coordination”, in Moradi, S., Kahkonen, K., Koskela, L., Klakegg, O.J. and Aaltonen, K. (Eds), *Routledge Handbook of Collaboration in Construction*, 1st ed., Routledge, pp. 4-16, doi: 10.1201/9781003379553-2.

Moradi, S. and Sormunen, P. (2025), “Deep collaboration and mutual trust in inter-organizational construction projects”, *Smart and Sustainable Built Environment*. doi: 10.1108/SASBE-10-2024-0435.

Moradi, S., Hirvonen, J. and Sormunen, P. (2024a), “Collaborative and life cycle-based project delivery for environmentally sustainable building construction: views of Finnish project professionals and building operation and maintenance experts”, *Smart and Sustainable Built Environment*, doi: 10.1108/SASBE-01-2024-0004.

Moradi, S., Kähkönen, K., Koskela, L., Klakegg, O.J. and Aaltonen, K. (2024b), *Routledge Handbook of Collaboration in Construction*, 1st ed., CRC Press LLC, doi: 10.1201/9781003379553.

Nwajei, U.O.K., Bølviken, T. and Hellström, M.M. (2022), “Overcoming the principal-agent problem: the need for alignment of tools and methods in collaborative project delivery”, *International Journal of Project Management*, Vol. 40 No. 7, pp. 750-762, doi: 10.1016/j.ijproman.2022.08.003.

Oraee, M., Hosseini, M.R., Edwards, D. and Papadonikolaki, E. (2022), “Collaboration in BIM-based construction networks: a qualitative model of influential factors”, *Engineering Construction and Architectural Management*, Vol. 29 No. 3, pp. 1194-1217, doi: 10.1108/ECAM-10-2020-0865.

Pablo, Z. and London, K.A. (2020), “Stable relationality and dynamic innovation: two models of collaboration in SME-driven offsite manufacturing supply chains in housing construction”, *Engineering Construction and Architectural Management*, Vol. 27 No. 7, pp. 1553-1577, doi: 10.1108/ECAM-07-2019-0346.

Patel, H., Pettitt, M. and Wilson, J.R. (2012), “Factors of collaborative working: a framework for a collaboration model”, *Applied Ergonomics*, Vol. 43 No. 1, pp. 1-26, doi: 10.1016/j.apergo.2011.04.009.

Pe-Mora, F., Tamaki, T. and Member, S. (2001), “The effect of delivery systems on collaborative negotiations for large-scale infrastructure projects”, *Journal of Management in Engineering*, Vol. 17 No. 2, doi: 10.1061/(ASCE)0742-597X(2001)17:2(105).

Pirayesh Neghab, A., Etienne, A., Kleiner, M. and Roucoules, L. (2015), “Performance evaluation of collaboration in the design process: using interoperability measurement”, *Computers in Industry*, Vol. 72, pp. 14-26, doi: 10.1016/j.compind.2015.03.011.

Qiao, S., Wang, Q., Guo, Z. and Guo, J. (2021), “Collaborative innovation activities and BIM application on innovation capability in construction supply chain: mediating role of explicit and tacit knowledge sharing”, *Journal of Construction Engineering and Management*, Vol. 147 No. 12, 04021168, doi: 10.1061/(asce)co.1943-7862.0002197.

Rashidian, S., Drogemuller, R., Omrani, S. and Banakar, F. (2024), “A review of the interrelationships and characteristics of building information modeling, integrated project delivery and lean construction maturity models”, *Smart and Sustainable Built Environment*, Vol. 13 No. 3, pp. 584-608, doi: 10.1108/SASBE-10-2022-0236.

Ren, Z., Anumba, C.J. and Yang, F. (2013), “Development of CDPM matrix for the measurement of collaborative design performance in construction”, *Automation in Construction*, Vol. 32, pp. 14-23, doi: 10.1016/j.autcon.2012.11.019.

Sattar, A., Ahmad, M.N., Surin, E.S.M. and Mahmood, A.K. (2021), “An improved methodology for collaborative construction of reusable, localized, and shareable ontology”, *IEEE Access*, Vol. 9, pp. 17463-17484, doi: 10.1109/ACCESS.2021.3054412.

Saunders, M.N.K., Lewis, P. and Thornhill, A. (2019), *Research Methods for Business Students*, 8th ed., Pearson Education, Harlow.

Savolainen, J.M., Saari, A., Männistö, A. and Kähkonen, K. (2018), “Indicators of collaborative design management in construction projects”, *Journal of Engineering, Design and Technology*, Vol. 16 No. 4, pp. 674-691, doi: 10.1108/JEDT-09-2017-0091.

Staykova, G. and Underwood, J. (2017), “Assessing collaborative performance on construction projects through knowledge exchange A UK rail strategic alliance case study”, *Engineering Construction and Architectural Management*, Vol. 24 No. 6, pp. 968-987, doi: 10.1108/ECAM-08-2016-0179.

Su, J., Yang, Y. and Zhang, N. (2017), “Measurement of knowledge diffusion efficiency for the weighted knowledge collaboration networks”, *Kybernetes*, Vol. 46 No. 4, pp. 672-692, doi: 10.1108/K-09-2016-0229.

Tang, Y., Wang, G., Li, H. and Cao, D. (2018), “Dynamics of collaborative networks between contractors and subcontractors in the construction industry: evidence from national quality award projects in China”, *Journal of Construction Engineering and Management*, Vol. 144 No. 9, 05018009, doi: 10.1061/(asce)co.1943-7862.0001555.

van Leeuwen, J.P. and Fridqvist, S. (2006), “An information model for collaboration in the construction Industry”, *Computers in Industry*, Vol. 57 Nos 8-9, pp. 809-816, doi: 10.1016/j.compind.2006.04.011.

Wang, Y., Thangasamy, V.K., Hou, Z., Tiong, R.L.K. and Zhang, L. (2020), “Collaborative relationship discovery in BIM project delivery: a social network analysis approach”, *Automation in Construction*, Vol. 114, 103147, doi: 10.1016/j.autcon.2020.103147.

Wang, Z., He, Q., Locatelli, G., Wang, G. and Li, Y. (2023), “Exploring environmental collaboration and greenwashing in construction projects: integrative governance framework”, *Journal of Construction Engineering and Management*, Vol. 149 No. 11, 04023109, doi: 10.1061/jcemd4.coeng-13543.

Wang, Y., lu, H., Wang, Y., Yang, Z., Wang, Q. and Zhang, H. (2024), “A hybrid building information modeling and collaboration platform for automation system in smart construction”, *Alexandria Engineering Journal*, Vol. 88, pp. 80-90, doi: 10.1016/j.aej.2024.01.013.

Yap, J.B.H. and Lim, S.Y. (2023), “Collaborative project procurement in the construction industry: investigating the drivers and barriers in Malaysia”, *Journal of Construction in Developing Countries*, Vol. 28 No. 1, pp. 171-192, doi: 10.21315/jcdc-10-21-0157.

Zhai, X., Reed, R. and Mills, A. (2014), “Addressing sustainable challenges in China: the contribution of off-site industrialisation”, *Smart and Sustainable Built Environment*, Vol. 3 No. 3, pp. 261-274, doi: 10.1108/SASBE-02-2014-0008.

Zhan, C., Fu, C. and Wu, X. (2023), “Research on collaborative construction management of construction project based on BIM technology”, *International Journal of Critical Infrastructures*, Vol. 19 No. 1, pp. 79-93, doi: 10.1504/IJCIS.2023.10040661.

Zhang, N., Hwang, B.G., Deng, X. and Tay, F. (2020a), “Collaborative contracting in the Singapore construction industry: current status, major barriers and best solutions”, *Engineering Construction and Architectural Management*, Vol. 27 No. 10, pp. 3115-3133, doi: 10.1108/ECAM-08-2019-0451.

Zhang, R., Wang, Z., Tang, Y. and Zhang, Y. (2020b), “Collaborative innovation for sustainable construction: the case of an industrial construction project network”, *IEEE Access*, Vol. 8, pp. 41403-41417, doi: 10.1109/ACCESS.2020.2976563.

Zhang, N., Hwang, B.G., Deng, X. and Tay, F. (2024), "Exploring critical success factors for collaborative contracting implementation in the Singapore construction industry", *Engineering Construction and Architectural Management*, Vol. 31 No. 2, pp. 919-938, doi: 10.1108/ECAM-05-2022-0398.

Zhao, D., McCoy, A.P., Bulbul, T., Fiori, C. and Nikkhoo, P. (2015), "Building collaborative construction skills through BIM-integrated learning environment", *International Journal of Construction Education and Research*, Vol. 11 No. 2, pp. 97-120, doi: 10.1080/15578771.2014.986251.

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