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Bridging Crew Dynamics and Lean Construction Principles: Defining Crew Choreography in Construction Operations

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Abstract

Question: How have research trends and thematic structures related to Crew Design, Crew Planning, and Work Structuring evolved in the literature, and how can these trends be synthesized to conceptually define Crew Choreography within the context of Lean Construction and construction operations?

Purpose: This study aims to introduce and define Crew Choreography, merging the core elements of Crew Planning, Crew Design, and Work Structuring within construction.

Research Method: A bibliometric analysis, specifically a co-word analysis, was conducted using Scopus and VOSviewer to examine research publications related to the keywords "Crew Design," "Crew Planning," and "Work Structuring." Additionally, we provided a contextual background for Crew Choreography based on the database collected for our co-word analysis.

Findings: Trends in the past 15 years, identifying recurring themes, gaps, and emerging areas within Crew Design, Crew Planning, and Work Structuring. Visualizations highlight keyword correlations and research evolution, offering a roadmap for future studies in these domains.

Limitations: The study relies on the Scopus database, excluding other databases. Additionally, as a qualitative study, it lacks quantitative or case-based validation.

Implications: The study proposes a clear definition of Crew Choreography, positioning it as a novel concept in construction management.

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Value for authors: The study introduces a new concept—Crew Choreography—that enriches Lean Construction theory and practice. This definition is a foundation for future research and practical applications in construction operations.

Keywords: Crew Choreography, Crew Planning, Crew Design, Work Structuring, Lean Construction, Bibliometric Analysis, Co-Word Analysis, Scopus, VOSviewer.

Paper type: Full paper

Introduction

Crew Choreography, within the context of construction management, involves the process of designing and organizing construction work teams. This entails carefully planning and structuring the crew's composition and specific roles and responsibilities. It encompasses determining the crew's makeup, the order in which tasks are performed, and the coordination of work assignments among team members. Although the term “Crew Choreography” itself hasn’t been explicitly used in the literature, early work by Nerwal and Abdelhamid 2012 addressed the possibility of choreographing construction crews. The aim is to improve the crew's performance and efficiency in construction activities. This concept is a fundamental aspect of the lean-oriented Crew Design principles introduced in research, with the overarching objective of reducing waste (non-value-added work) and maximizing value (value-added work) in construction operations (Nerwal 2012). However, despite its conceptual relevance, the notion of Crew Choreography remains insufficiently defined and underdeveloped in existing literature.

A major part of production system design is coordinating multiple work teams on dynamic construction sites. This inter-team coordination presents complex challenges, as it involves managing diverse skills and specialties within high-stakes and rapidly changing environments (Jain et al. 2023). Effective team coordination is essential for timely project delivery and requires clear communication, conflict resolution, and adaptability to unplanned conditions.

Similarly, and perhaps even more so, the intra-teamwork Structuring is rather complex. This has generally been left to long-standing adopted crew practices. To further the work in this area, the idea behind Crew Choreography was conceived by Abdelhamid back in 2008 informally through an unpublished material, and published research conducted by Nerwal and Abdelhamid (2012) , but a proper definition of this concept is yet to be determined. Crew Choreography, a method grounded in lean thinking principles, addresses these challenges by structuring intra-team interactions to minimize waste and enhance value through efficient workflows and precise task alignment (Nerwal 2012).By focusing on context and situational-based Crew Design, Crew Choreography ensures that each team's contributions are sequenced effectively, reducing downtime and improving activity outcomes. This approach will continue to gain importance as construction projects become complex, necessitating meticulous planning and coordination to balance competing demands for speed, quality, and cost-efficiency.

We aim to define Crew Choreography through three core aspects of Lean Construction: Crew Design, Crew Planning, and Work Structuring. First, Crew Design involves a deliberate structuring of each crew member, organized around task requirements and workflow priorities, aiming to optimize interactions and minimize delays between crew members (Nerwal and Abdelhamid 2012). Second, Crew Planning is when team composition is decided based on the skill levels and the size required for specific tasks. It ensures that each team member's abilities match the project requirements (Breugem et al. 2022). Finally, Work Structuring focuses on the sequencing of tasks and establishing dependencies among them, such as through the Last Planner System or Takt planning, which maintains continuous workflow and reduces inefficiencies(A. G. Frandson 2019) . Together, and for this paper, these topics embody the concept of Crew Choreography by making easy transitions between tasks, minimizing bottlenecks, and promoting resource management aligned with Lean Construction principles to maximize project value and minimize waste.

A conceptual definition of Crew Choreography is essential, as the concept currently lacks research defining its scope and practical applications in Lean Construction. Although other innovative practices have been studied in broader construction contexts (Lehtovaara et al. 2022), Crew Choreography is underexplored. Conducting a bibliometric analysis provides a comprehensive view of research trends and emerging clusters, which helps uncover important patterns and developments within this niche (Loganathan et al. 2018). This tool will facilitate the identification of significant research gaps and, thus, guide future studies to optimize crew coordination and improve productivity across complex construction projects.

Despite the growing body of literature on Crew Design, Crew Planning, and Work Structuring within Lean Construction, several gaps remain. First, these domains have predominantly been studied in isolation, with limited efforts to conceptually integrate them into a unified framework that captures their interdependence in real-world construction operations. Second, while the notion of “Crew Choreography” has been implicitly referenced in prior work (Nerwal and Abdelhamid 2010, 2012), it lacks a formalized definition, clear scope, and theoretical grounding within Lean Construction discourse. Third, there is a lack of systematic, data-driven synthesis of existing research trends that could reveal how these themes have evolved and where meaningful intersections exist. As a result, the field currently lacks a cohesive conceptual lens to understand and optimize intra- and inter-crew dynamics. Addressing these gaps is essential to advancing both theoretical development and practical applications in construction operations.

In response to the identified gaps, this study aims to achieve the following objectives. First, map and analyze the evolution of research trends related to Crew Design, Crew Planning, and Work Structuring using a bibliometric co-word analysis approach. Second, identify thematic clusters, knowledge structures, and underexplored areas within these domains. Third, synthesize these insights into a coherent conceptual foundation that supports the formal definition of Crew Choreography. Finally, the study seeks to position Crew Choreography within Lean Construction theory and highlights its potential implications for improving coordination, workflow efficiency, and value generation in construction operations.

Literature review

Lean Construction revamps how value is conceived, designed, and delivered in the built environment. This philosophy, rooted in Lean Manufacturing, doesn't lie in maximizing value and minimizing waste, as often cited, but rather focuses on achieving the best possible value to the client through system-thinking, reliability, and collective understanding among all participants. Ideally, Lean Thinking in the Construction Industry (LTCI) aspires to a stage where design and construction generate value by (Abdelhamid and Copeland 2022):

1. Reaching a shared, early understanding of client needs and expectations.
2. Doing the right things right the first time.

This Lean approach integrates efficiency through collaboration, learning, and respect for people. In addition, it establishes management tools such as conceptual estimating, CPM scheduling, or work breakdown structures (Howell 1999, Ballard 2008).

This philosophy, rooted in Lean manufacturing, emphasizes collaboration, transparency, and respect for people. As a matter of fact, Lean Construction addresses inefficiencies such as the 3M (Muda "Waste", Mura "Unevenness/Irregularity", and Muri "Overburden/Overload) and fosters flow efficiency and continuous improvement (Kaizen) (Bajjou and Chafi 2018). Furthermore, Lean Construction aims to transform traditional, fragmented processes into a predictable, value-driven system (Bajjou and Chafi 2018, Bajjou et al. 2017). In short, Lean Construction provides a framework for transforming the traditional, fragmented production model into a predictable, value-driven process, emphasizing flow, coordination, and commitment-based planning (Bajjou and Chafi 2018; Bajjou et al. 2017).

Within this context, production planning and control systems like the Last Planner System® became essential for improving workflow reliability and task-level coordination (Tamošaitienė and Starta 2019). Nevertheless, despite process-level improvement, the human and crew-level coordination are often underemphasized by these systems (Dongari and Munagala 2024).

In construction management generally and Lean Construction specifically, crews serve as the link between planning and execution, thus, they represent the operational backbone of project delivery. Therefore, their composition (crew size/ crew make-up), coordination (order in which the tasks are performed/ work assignments among crew members/ movements and actions of each member of the construction crew), and adaptability (optimize skills and abilities of workers involved in the construction project for continuous workflow) are essential to achieving Lean goals. As emphasized by (Nerwal and Abdelhamid 2012), reliability and quality outputs depend on how efficiently crews function as a solid production unit.

Within this framework, three interrelated concepts are highlighted: Crew Design, Crew Planning, and Work Structuring. Crew Design focuses on composing teams with the right skills and roles (Nerwal 2012). Crew Planning emphasizes synchronizing team schedules and activities to minimize idle time and conflicts (Bjarnason 2015). Meanwhile, Work Structuring ensures the logical organization of tasks for a continuous workflow (Frandson 2019). These three areas have been studied in isolation, and there is a need to integrate them for a more human-centered approach.

Several production planning techniques and tools like the Last Planner System® (Ballard 2020), Takt Planning (Frandson et al. 2014), Production Control models (Pradhan 2019) have improved schedule reliability and workflow synchronization. As a matter of fact, these frameworks allow teams to visualize dependencies, align project milestones, and reduce variability (Pérez et al. 2019). However, as good as they are on a macro-level, they neglect the micro-dynamics of human coordination such as situational interactions among field crews that are essential for achieving sustained production stability (Saurin and Rooke 2020).

Another limitation in production planning and control models is the way crews are treated as interchangeable units, rather than interdependent teams (Moore 2013; Desai and Abdelhamid 2012). Research conducted by (Power et al. 2024b) highlights how the integration of LPS® and takt, while enhancing productivity, overlooks how human factors (communication, leadership, and team learning) shape execution on site. Saurin and Rooke (2020) further argue that production planning and control in construction need to recognize that human coordination is emergent and context-dependent, which is poorly captured by current Lean frameworks.

At this point, we can notice a clear disconnection between process-oriented planning tools and human coordination. In fact, we can further argue, theoretically, that there is a need for advanced integrative models that explain how crew-level coordination dynamically works. Furthermore, from an empirical perspective, there is a lack of definitions and metrics to measure crew-level synchronization. Addressing this gap necessitates a synthesis of various insights: production theory, cognitive systems engineering, and Lean practice (Power et al. 2024a).

The selection of Crew Design, Crew Planning, and Work Structuring is not random but rather captures the representation that shapes how production unfolds in Lean Construction. As a reminder, Crew Design refers to who performs the work, and it involves multiple aspects (e.g., team composition, skill alignment, role clarity) (Nerwal and Abdelhamid 2012). Crew Planning, by contrast, defines when and how crews perform their work, it features synchronization, sequencing, and coordination (Biotto and Kagioglou 2020). Lastly, Work Structuring specifies what tasks are performed and in what order (Franco and Picchi 2016).

These three keywords map directly to core Lean Construction principles:

- Crew Design ➔ Value generation by assigning the right people to the right roles.
- Crew Planning ➔ Flow and reliability through coordinated and predictable work execution.
- Work Structuring ➔ Waste minimization by efficiently sequencing tasks.

Together, this triad captures the crew-centric dimension of Lean Construction that many production planning frameworks tend to overlook. As noted by Skaar et al. (2020), there is a need to anchor production improvements not only in process but also in human-centered execution. Thereupon, conducting a bibliometric analysis on these three concepts would allow a deeper understanding of how people, processes, and principles interact to achieve Lean's objectives.

Through this literature review, we underscore the need for a framework that focuses on coordinating and synchronizing crews as dynamic entities. The concept we aim to define in this article extends traditional production planning approaches by positioning the crew at the center of Lean implementation. To do so, we need to understand how the existing literature has treated crew-related topics within the Lean Construction spectrum. Therefore, the present bibliometric analysis addresses this gap by mapping the evolution of studies on Crew Design, Crew Planning, and Work Structuring, while providing the necessary conceptual foundation to define the emerging topic of Crew Choreography.

Methodology

In our study, we employed a bibliometric study to explore and assess the available literature on Crew Design, Crew Planning, and Work Structuring in the context of Lean Construction and construction management. A bibliometric analysis identifies emerging fields and repetitive themes that shape current practices within a particular domain (Kedir and Fayek 2023). It helps to visualize research contributions and provides a structured understanding of the intellectual landscape related to the topic studied(Lehtovaara et al 2022).

We selected the Scopus database to collect our data for its extensive coverage of peer-reviewed journals, conference proceedings, and book chapters, as well as its rigorous selection criteria that ensure high-quality publications (Baas et al. 2020). We carefully selected a set of keywords to ensure a focused and relevant dataset. The primary keywords used in this study include “Crew Design,” “Crew Planning,” and “Work Structuring,” each selected for its relevance to the concept of Crew Choreography. We filtered the publications in English by publication years, focusing on works published within 15 years from 2010 to January 11, 2025, to reflect recent developments in the field. A 1st refinement excluded documents with undefined authors from our dataset (articles, conference papers, book chapters, and reviews). Subsequently, a 2nd refinement removed duplicate records. Finally, we exported our dataset to Excel for manual screening.

After data cleaning, we conducted a co-word analysis as the primary bibliometric technique proposed by Callon et al. (1983). This technique examines the co-occurrence frequency of the written content, e.g., title, abstract, or author keywords (Emich et al. 2020). This method identifies clusters of related terms, thereby highlighting emerging themes and areas within a field (Donthu et al.2021).

To visualize these patterns, we used VOSviewer (van Eck and Waltman 2010) because of its strong features in mapping and clustering bibliographic documentation. This software is ideal for handling large datasets and provides detailed visualizations that facilitate the identification of relationships within research and academic literature.

To explore these relationships visually, we opted for two main visualization modes:

- **Network visualization:** Represents the connections between keywords and research clusters. This visualization mode shows how frequently terms co-occur and how closely they are related across the dataset (Donthu et al. 2021).
- **Overlay Visualization:** Provides a visual representation of how important the research community engages with a work overtime (Bornmann and Haunschild 2016) .

The following section summarizes the steps followed for this analysis:

- **Step 1: Data Collection**
  - Database: Scopus
  - Timeframe: 2010 - January 11, 2025
  - Language: English only (for comparability)
  - Document type: Articles, conference papers. book chapters, and reviews.
- **Step 2: Data Cleaning and Preparation**
  - Removing documents with undefined authors
  - Removing the documents not aligned with the scope of Lean Construction and Crew-related research
- **Step 3: Bibliometric Analysis**
  - Software: VOSviewer
  - Science Mapping technique: Co-word Analysis (Title/Abstract/Authors Keywords/Indexed Keywords).
  - Output: Network and Overlay Visualization map
- **Step 4: Thematic Spectrum Analysis**
  - Identifying thematic clusters and research patterns
  - Mapping the research spectrum surrounding the chosen concepts
- **Step 5: Gap Identification**
- **Step 6: Conceptual Definition**

Results

In this section, we will present the findings from the bibliometric analysis conducted on “Crew Design”, “Crew Planning”, and “Work Structuring”. We analyzed each topic and revealed the network and overlay visualization to reveal recurring themes and focus areas. This analysis also examines trends over time to demonstrate how the research focus on these areas has evolved, ultimately supporting a more comprehensive understanding of Crew Choreography in Lean Construction.

Crew Design

Since Crew Choreography relies on understanding the roles, skills, and organization of team members, Crew Design is a fitting starting point.

The initial search in the Scopus database returned 97 publications. After applying the established filters, the sample was refined to 52 publications.

In analyzing the Crew Design database using VOSviewer, we conducted a co-occurrence analysis focusing on both author and indexed keywords. Initially, this approach identified 544 unique keywords. We applied a threshold to enhance relevance, selecting only keywords with a minimum of 3 occurrences, and reducing the set to 27.

Network Visualization

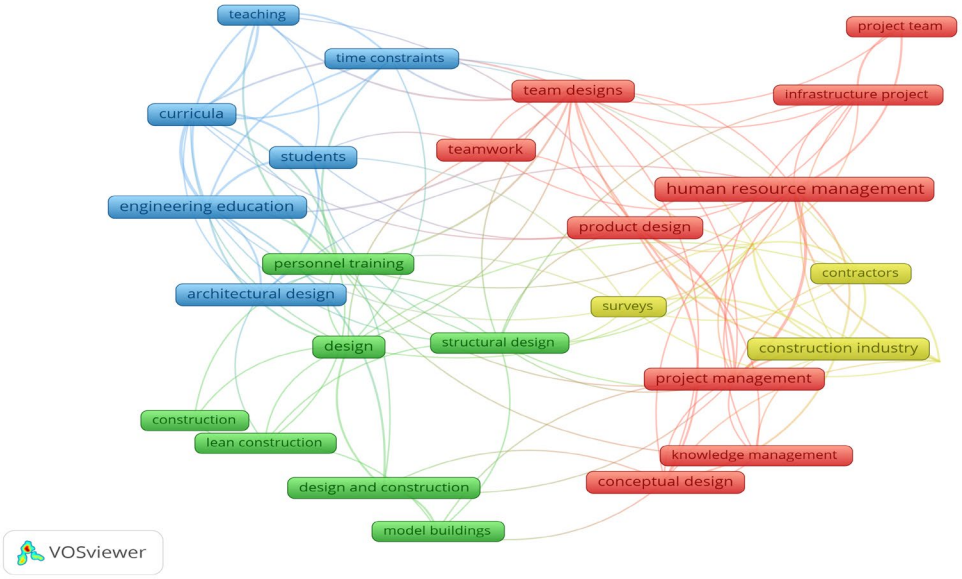

Figure 1: Network Visualization Map

Overlay Visualization

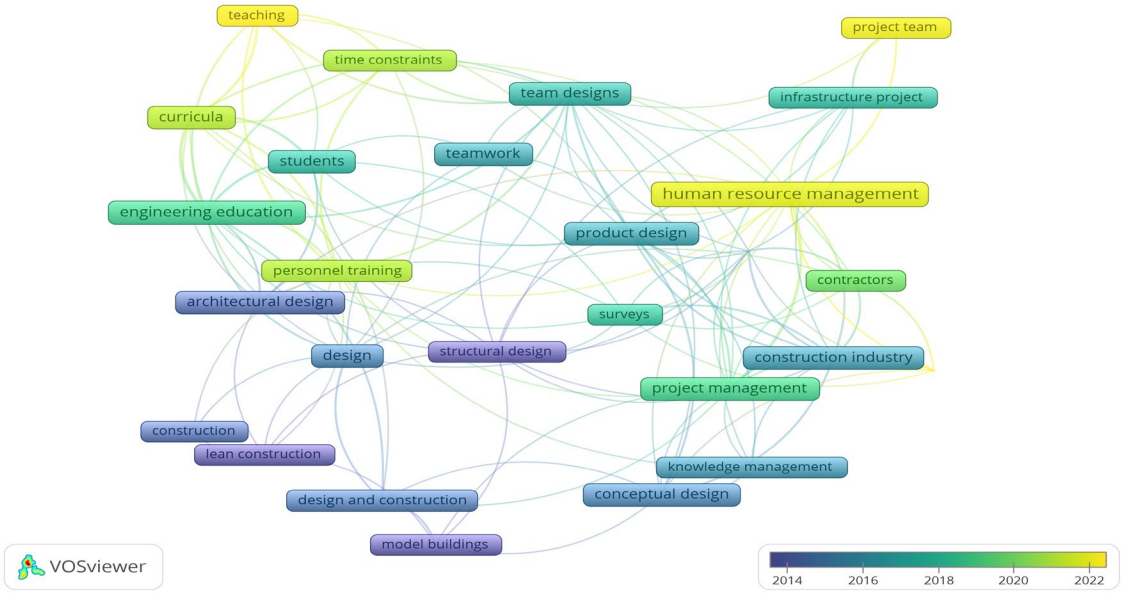

Figure 2: Overlay Visualization Map

Keyword Mapping Table

Table 1: Keyword Mapping Table for Crew Design

Cluster	Top Keywords	Occurrence	Peak Citation Year
Red	Human Resource Management	11	2021
	Conceptual Design	6	2015
Blue	Engineering Education	7	2018
	Curricula	6	2022
Green	Design	6	2015
Yellow	Construction Industry	6	2016

Crew Planning

After establishing Crew Design, Crew Planning is the next step, as it builds on the designed crew structure to organize and coordinate tasks. Planning involves scheduling, assigning roles, and optimizing the timing of activities, which is essential for an effective choreography of the crew's movements.

The search initially identified 453 publications, which were then refined to 265 publications.

In analyzing the Crew Planning database through co-word analysis using the VOSviewer software, we identified 2,616 keywords within the dataset. Applying a threshold to select keywords with a minimum occurrence of 10, the list was reduced to 29, and 3 keywords were removed because they didn't have an actual referential meaning, resulting in a final list of 26.

Network Visualization

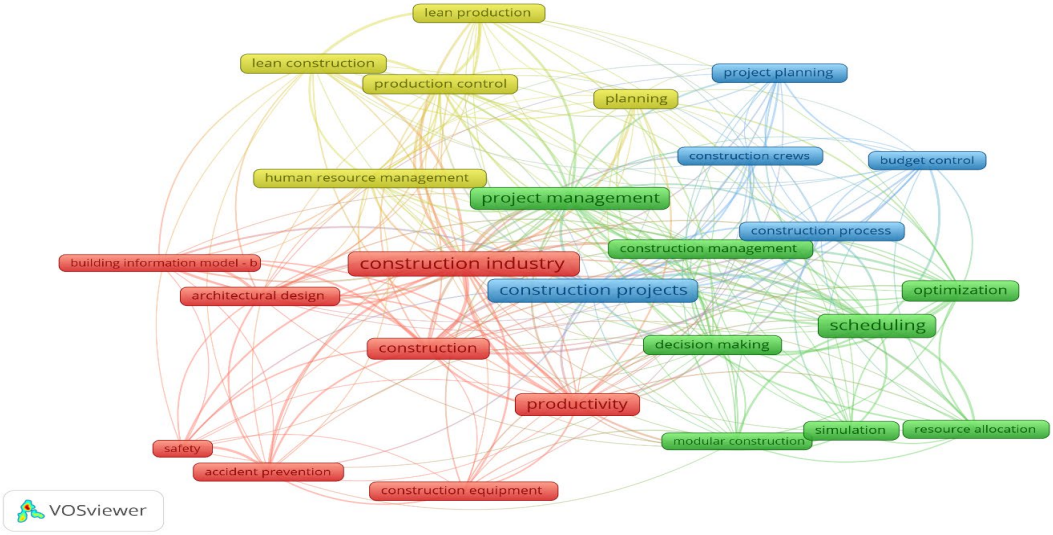

Figure 3: Network Visualization Map

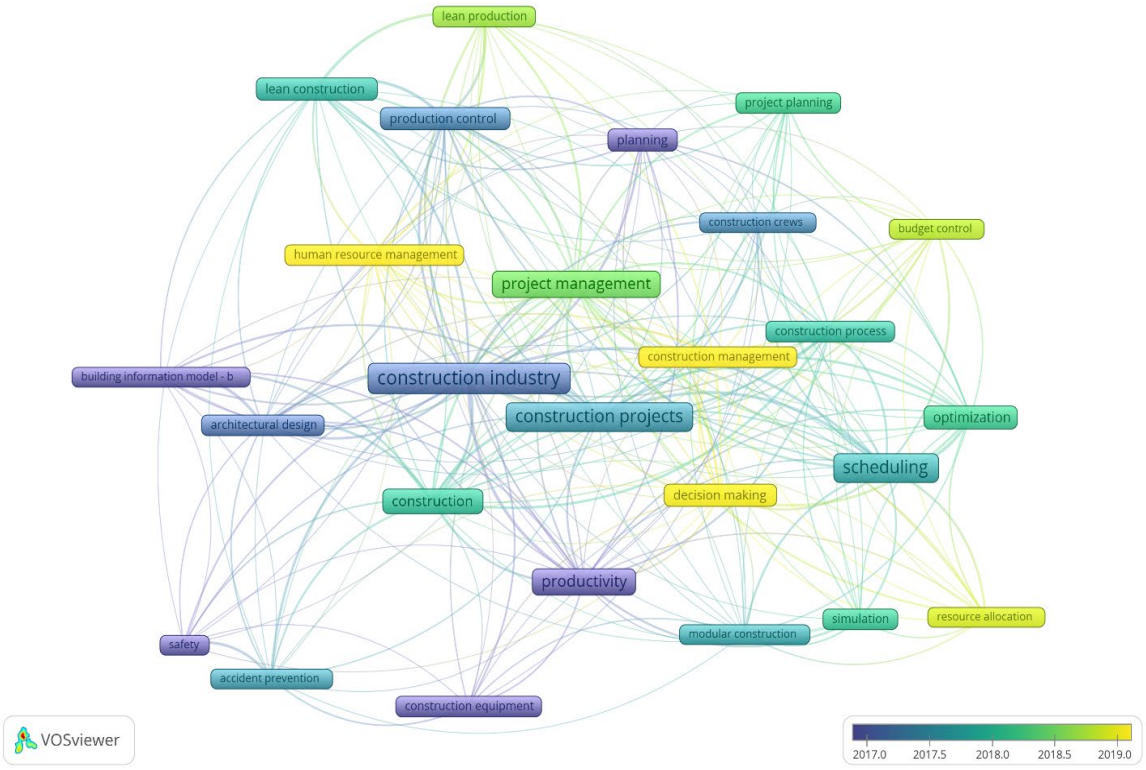

Figure 4: Overlay Visualization Map

Keyword Mapping Table

Table 2: Keyword Mapping Table for Crew Planning

Cluster	Top Keywords	Occurrences	Peak Citation Year
Red	Construction Industry	51	2017
	Productivity	34	2017
	Construction	27	2018
Blue	Construction Projects	42	2017
	Decision Making	18	2019
	Simulation	17	2018
Green	Scheduling	41	2018
	Project Management	36	2018
	Optimization	24	2018
Yellow	Production Control	20	2017
	Planning	19	2017
	Lean Construction	18	2018

Work Structuring

Finally, Work Structuring can be addressed. This element focuses on sequencing tasks and aligning activities to optimize workflow across the entire operation, which ties together the principles of design and planning in the execution phase.

The search string is:

The initial search yielded 93 publications, and after applying the refinements, the final dataset consisted of 45 publications.

In the co-word analysis conducted for the Work Structuring database using the VOSviewer software, we identified a total of 435 keywords within the dataset. After applying a threshold that required a minimum occurrence of 4, the list was narrowed down to 19 keywords, and one redundant keyword was subsequently removed, resulting in 18.

Network Visualization

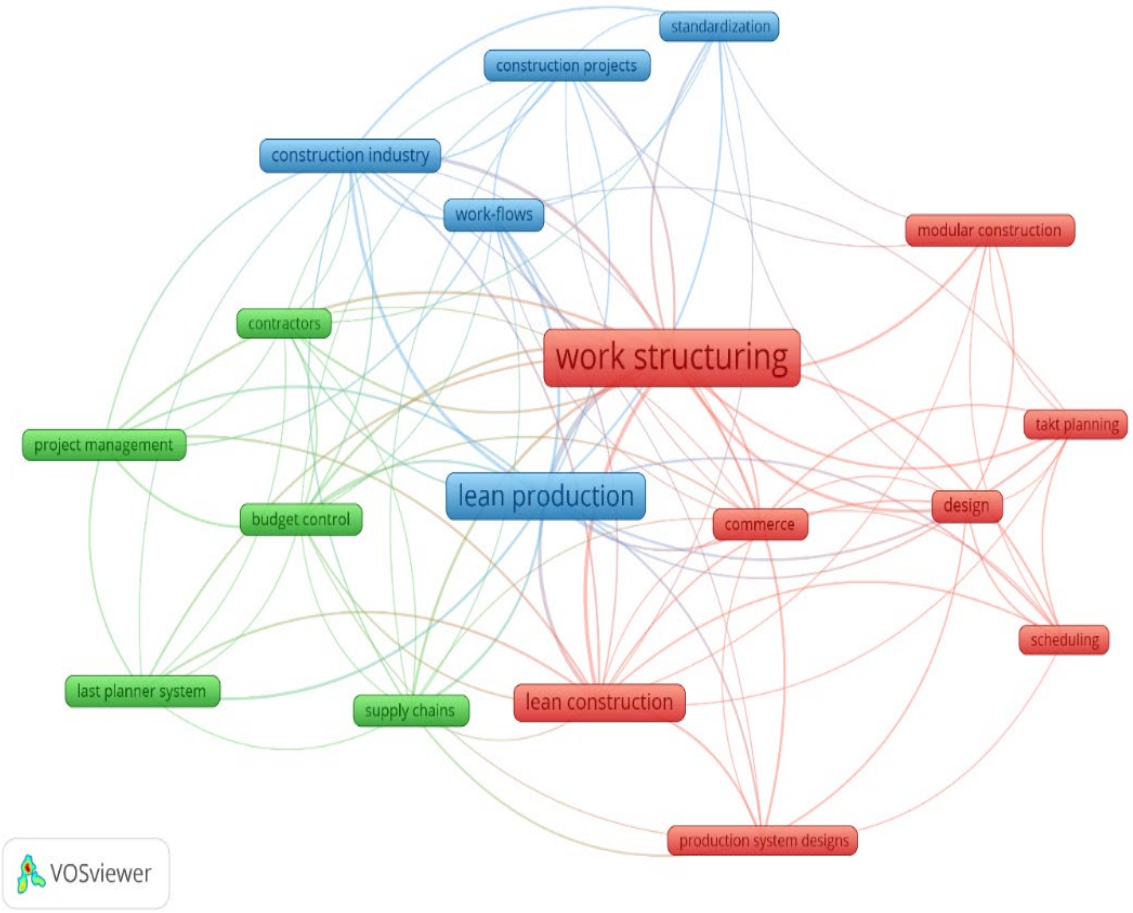

Figure 5: Network Visualization Map

Overlay Visualization

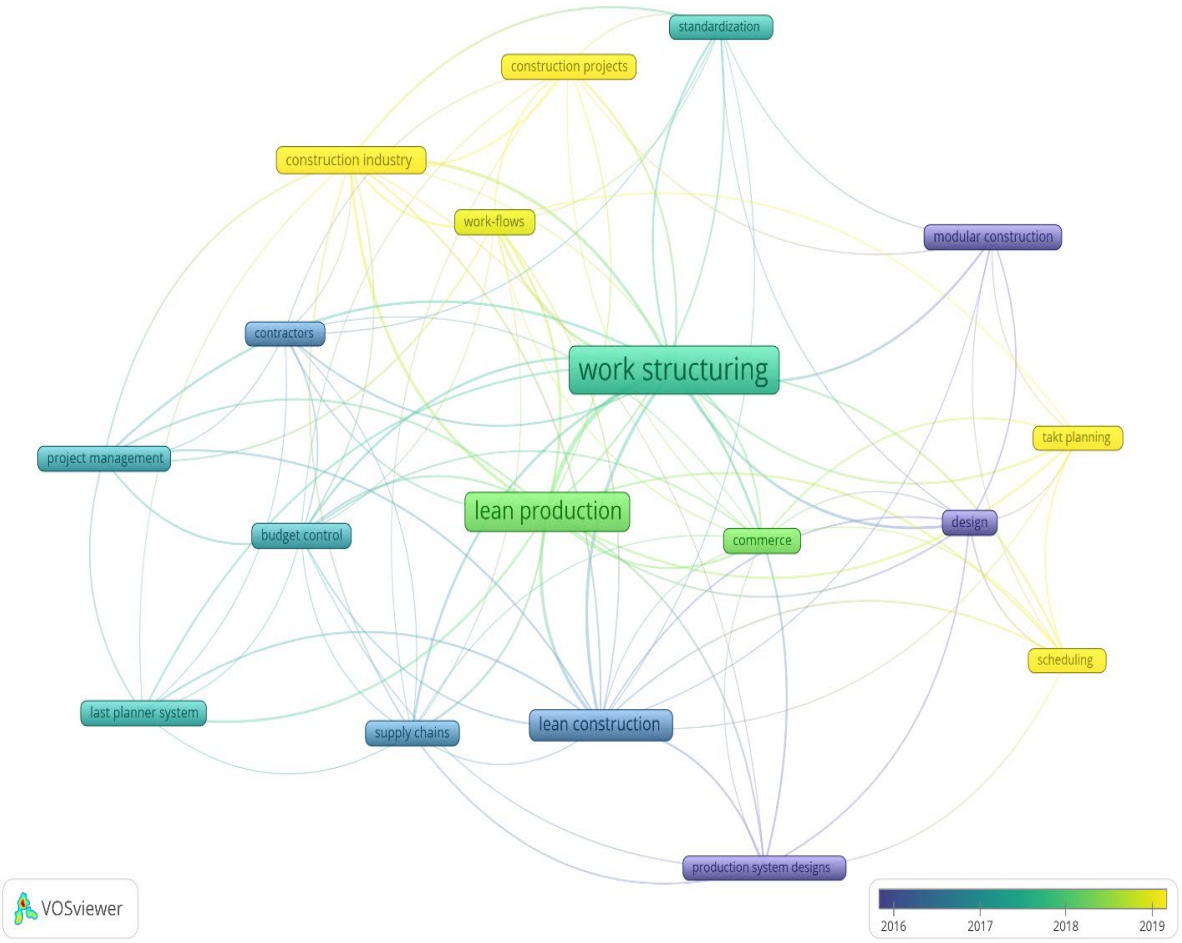

Figure 6: Overlay Visualization Map

Keyword Mapping Table

Table 3: Keyword Mapping Table for Work Structuring

Cluster	Top Keywords	Occurrences	Peak Citation Year
Red	Work Structuring	28	2017
	Lean Construction	11	2016
	Design	6	2016
Blue	Lean Production	19	2018
	Construction Industry	7	2019
Green	Last Planner System	5	2017
	Budget Control	5	2017

Theme Clusters

The table below highlights the key themes and ideas presented in the network visualization maps.

Table 4: Theme Cluster interpretation

Key concepts	Clusters	Theme	Key Ideas
Crew Design	**Red**	Project Teams and Management.	The importance of managing teams, knowledge-sharing, and collaboration in design and construction projects
	Green	Design and Construction Processes	The integration of Lean Construction principles and training in improving design and construction practices
	Blue	Education and Training	Preparing future construction professionals through education and curriculum development
	Yellow	Decision-Making and Industry Practices	The role of decision-making and feedback mechanisms in managing construction projects effectively
Crew Planning	**Red**	Safety and Productivity in Construction	The importance of digital tools and safety measures in improving crew efficiency
	Green	Project Optimization and Management	Efforts to streamline project workflows through better resource use and planning strategies
	Blue	Project Planning and Processes	Managing crews effectively to meet budget and time constraints
	Yellow	Lean Production and Human Resource Management	The shift towards Lean Construction methodologies and efficient workforce management in construction projects
Work Structuring	**Red**	Core Concepts of Lean Construction and Work Structuring	Focus on the core principles of Lean Construction and the planning strategies used to enhance production efficiency, with an emphasis on modular and takt-based approaches to improve workflow and optimize construction processes.
	Green	Project Management and Control	Themes related to cost management, planning systems (Last Planner System), and supply chain coordination, emphasizing the importance of collaborative planning and budget control mechanisms to enhance project performance.
	Blue	Standardization and Workflow Optimization	The standardization of processes within the construction industry, focusing on workflow efficiency and Lean Production methods aimed at reducing variability and improving consistency across projects

Theme's evolution over time

The figures below showcase how the research spectrum evolves based on the overlay visualization maps.

Crew Design

- 2014: Exploration of integrating design with construction practices.
- 2015-2016: Project execution and industry-specific applications.
- 2018: Team dynamics and educational efforts in construction.
- 2020: Specialized training and learning systems for better Crew Design.
- 2022: Training construction professionals and optimizing team structures.

Crew Planning

- Late 2016 / Early 2017: Enhance planning processes and integrate digital tools.
- Mid 2017: Integrating design aspects with planning efforts.
- Late 2017: Safety and prefabrication strategies in Crew Planning.
- Early 2018: Efficiency improvement through planning techniques.
- Mid 2018: Cost efficiency and Lean Construction practices.
- Late 2018 / Early 2019: Effective resource management for better Crew Planning.

Work Structuring

- Early 2016: Modular and systematic production design.
- Late 2016 / Early 2017: Integration of Lean principles into construction supply chains.
- 2017: Project Efficiency through management, budgeting, and standardization.
- 2018: Expansion of Lean philosophy into the commercial sector.
- Late 2018 / Early 2019: Evolving themes of Work Structuring.

Discussion

Result Interpretation

Crew Design

The bibliometric results of Crew Design highlight foundational elements that directly relate to the concept of Crew Choreography. The network visualization reveals four dominant themes, each corresponding to a key dimension of how crews are structured and coordinated. These themes collectively emphasize that Crew Design is not limited to assembling personnel but involves aligning roles, competencies, and learning mechanisms to support coordinated task execution.

The overlay visualization further shows a clear evolution from early efforts to integrate design and construction practices toward a stronger emphasis on team dynamics, specialized training, and optimized team structures. This evolution demonstrates how intentional Crew Design enables smoother task sequencing, improved coordination, and adaptive team behavior.

Crew Planning

The analysis of Crew Planning focuses on how crews are deployed over time. The identified clusters underscore the crucial role of planning in aligning crew activities with project objectives. These themes indicate that effective Crew Planning not only sets the tone for when tasks are performed but also how crews interact with workflows, safety requirements, and resource constraints.

The temporal evolution shows progression from enhanced planning processes and digital tool integration toward Lean Construction practices and effective resource management. These findings demonstrate that planning orchestrates crew movements, task handoffs, and workload balance, ensuring that crews perform in a coordinated and rhythmic manner.

Work Structuring

The result of Work Structuring provides the process-oriented backbone of how to choreographically design construction crews. Network visualization emphasizes structuring work in a way that stabilizes production, reduces variability, and supports predictable crew interactions.

The overlay visualization reveals an evolution from modular and systematic production design towards broader integration of Lean principles, standardization, and workflow optimization across sectors. These results establish the “stage” upon which crews perform and enable them to move cohesively, minimize interruptions, and maintain flow.

Gap Identification

The bibliometric studies of Crew Design, Crew Planning, and Work Structuring reveal a common focus on optimizing the performance of construction teams. Across these studies, key themes like collaboration, resource allocation, and scheduling emerged as crucial factors for the success of construction projects. However, even if these topics have traditionally been studied separately (Ballard et al. 2001, Zhang et al. 2015, Hassanein and Melin 1997), the growing research spectrum highlights the need for a more integrated approach to managing crews on construction sites (Nerwal 2012).

The overlay visualization represents a timeline progression from key subjects, such as design and planning, to specific concepts, including lean production, standardization, and project management. This shift demonstrates that the focus in construction management is shifting toward dynamic coordination of crews to enhance productivity and efficiency. In this context, the concept of Crew Choreography comes to light, a framework that synchronizes crew activities through structured guidelines, similar to how a choreographer directs a dance to achieve a harmonious performance. Rather than treating crews as isolated units, Crew Choreography emphasizes the importance of orchestrating their movements collectively to optimize workflow, reduce waste, and enhance project performance.

Building on the insights gained from the bibliometric analysis, it becomes essential to ask: What exactly is Crew Choreography? Throughout this article, we have highlighted recurring themes of coordination, collaboration, and process optimization, all of which point

to a growing need for structured, synchronized crew management strategies (Nerwal and Abdelhamid 2010b). The term Crew Choreography has been introduced as a concept that integrates these elements, but what does it truly entail? How can construction crews be choreographed in a way that enhances their performance and aligns with the principles of Lean Construction? (Nerwal 2012).

Table 5: Conceptual evolution toward Crew Choreography

Component	Traditional Focus	Evolving Insight	Implications for Crew Choreography
Crew Design	role allocation, team composition	integration with lean, adaptability to task flow	Focus on structuring crews around value generation and coordination
Crew Planning	scheduling, sequencing	emphasis on real-time adjustments, collaboration	Planning for dynamic coordination and shared rhythms
Work Structuring	task breakdown, responsibility distribution	integration across traits and processes	Structured flow of tasks that supports choreography
Coordination	often implicit, task-based	recognized as a key performance driver	Elevated to central elements, intentional coordination across crew activities
Literature Gap	Concept treated in isolation	growing interest in integrated crew management	Need for a unifying framework, hence Crew Choreography

Conceptual definition: Crew Choreography

The results of the bibliometric analysis show that the literature has progressively converged to a new integrative concept. Let's break it down:

- Crew Design defines who performs the work and with which capabilities.
- Crew Planning determines when and under what conditions the work is performed.
- Work Structuring specifies how tasks are sequenced and coordinated.

Thus, the key contribution of this study, synthesized in the table below (table 6), lies in articulating a unifying concept that synthesizes these three streams, grounded in Lean Construction principles and aimed at improving coordination, efficiency, and value generation in construction operations.

Crew Choreography is not a typical denomination that we would find in literature. Although Nerwal & Abdelhamid (2010) addressed the question "Is it possible to choreographically design construction work crews, and if so, how?" a definition of Crew Choreography is still lacking. In their research, they investigated the feasibility of designing construction work rules in a manner akin to choreographing a dance.

Table 6: Relationship between Bibliometric Themes and Crew Choreography

Keyword	Key Themes Identified	Contribution to Crew Choreography
Crew Design	Team management, training, decision-making, and industry practices.	Defines crew composition, roles, competencies, and adaptive capacity.
Crew Planning	Safety, productivity, lean planning, and resource management.	Orchestrates task timing, crew deployment, and workload balance.
Work Structuring	Lean principles, workflow optimization, and standardization.	Structures task sequences and interactions to enable coordinated crew flow.

According to Nerwal and Abdelhamid (2012), this suggests that the focus should be on formulating a methodical approach to designing construction work crews that accounts for the specific demands of the production process and the competencies and capacities of the workers involved. Moreover, the query implies that there may be certain obstacles associated with designing construction work crews in this manner, specifically as they emphasized the intra-teamwork coordination. Therefore, a strong need to develop guidelines to design this Crew Choreography is required due to the lack of literature on this topic (Nerwal and Abdelhamid 2012). The table below (Table 7) frames the value proposition of our research by contrasting the old and new approaches.

Table 7: Traditional vs. Choreographic Crew Design

Aspect	Traditional Crew Design	Choreographic Crew Design
Primary Focus	Assigning manpower to tasks	Designing interactions, sequences, workflows, and handoffs.
Approach	Static, often based on experience.	Dynamic, iterative, and data informal.
Key Metrics	Man-hours, overall completion time.	Takt time, workload balance, synchronization, social cohesion, flow, and learning.
Worker View	Resource to be managed.	Skilled participant in a coordinated system.
Process	Linear (Plan ➔Execute).	Cyclical (Form ➔Execute ➔Refine ➔Re-form).

Based on the available literature and the bibliometric analysis conducted on Crew Planning, Crew Design, and Work Structuring, we identified key emerging themes that helped shape our understanding of Crew Choreography. Through this analysis, we were able to propose a definition that captures the essence of Crew Choreography as it stands today, recognizing that this concept may continue to evolve. The following definition reflects our current understanding and serves as a foundation for further development in the field:

Crew Choreography, in the realm of construction management, entails the deliberate and systematic process of devising and arranging intra-team construction work coordination. This involves meticulous planning and organizing of both the workforce's composition and their specific roles and duties. It encompasses the determination of the crew's composition, the sequence in which tasks are carried out, and the synchronization of work assignments among team members. The primary objective is to enhance the crew's performance and overall efficiency in construction activities. This concept constitutes a fundamental aspect of the lean-oriented Crew Design principles introduced in research, with the overarching goal of minimizing wastage (non-value-added work) and maximizing value (value-added work) in construction operations.

To better understand the concept of Crew Choreography, we suggest referring to the following table (Table 8), which provides a clear perspective on this concept.

Table 8: Crew Choreography - What It Is vs. What It Is Not

Crew Choreography IS…	Crew Choreography IS NOT…
Systematic, lean-oriented method of intra-team coordination	Abstract metaphor without actionable structure
Focused on synchronizing crew members' roles, tasks, and workflows	Merely assigning a task or role individually
Anchored in lean principles, reducing waste and maximizing value	Traditional scheduling or planning technique
Concerned with team dynamics, safety, and well-being	Focused only on output or production speed
Emerging from the integration of design, planning, and structuring concepts	A stand-alone process separated from other project management approaches

Similar to a set of dancers, the crew on a construction site adheres to certain rules and specific guidelines. The objective of the table below (Table 9) is to identify the major guidelines available in our dataset extracted from the literature, related to Choreographic Crew Design, specifically in construction projects.

Conclusions

Crew Choreography is the deliberate and systematic process of designing, organizing, and synchronizing the composition, roles, responsibilities, and task sequences of a construction work team. Its primary goal is to optimize crew performance and efficiency by enhancing intra-team coordination, thereby achieving desired outcomes in project management (Cost, Time, Quality, and Security) and advancing Lean Construction principles.

This study sets out to define Crew Choreography as a novel concept in construction management by integrating insights from Crew Planning, Crew Design, and Work Structuring. The research identified key trends, clusters, and gaps within these domains through a bibliometric analysis of relevant keywords and a comprehensive literature review. The

proposed definition highlights Crew Choreography as a critical framework for optimizing construction workflows, minimizing waste, and enhancing productivity, aligning closely with Lean Construction principles.

Table 9: Crew Choreography Design - A Synthesis of Literature

Focus Area	Insight from the literature	Core Concept	Key Researchers
Process & Standardization	Establish a systematic process with defined work rules, sequences, and deadlines. Use takt time to set the work pace and create a Standard Operations Routine.	Standardizing the work to create a predictable and measurable workflow.	(Hassanein and Melin 1997, Monden 2011, Fazinga et al. 2016)
Performance Optimization	Develop mathematical models to determine optimal crew performance based on synchronization, sequence, number of shifts, and unit productivity.	Using quantitative data to fine-tune the crew's timing for peak efficiency.	(Lapidus and Abramov 2018)
Workload & Safety	Implement frameworks for equitable task assignments to balance workload and mitigate uneven fatigue rates within the crew, enhancing safety.	Ensuring no single worker is overburdened, which disrupts the entire crew's performance and safety.	(Ahmadian et al. 2018)
Data-Driven Forecasting	Utilize advanced computational models (e.g., Deep Learning, Decision Support Systems) to predict productivity and optimize crew size and composition for future projects.	Using predictive analytics to "rehearse" and plan the optimal crew makeup before the project begins.	(Song and Perez 2022; Perez et al. 2022)
Multidisciplinary Factors	Integrate principles from industrial engineering psychology and socio-technical systems. Consider crew formation, social cohesion, leadership, and task clarity.	Acknowledging that a crew is a social system, its chemistry is as important as its technical skills.	(Nerwal and Abdelhamid 2012)
Iterative Process	Adopt a three-phase iterative cycle: Formation (structuring), Execution (data collection), and Refining (analysis and improvement).	Choreography is not a one-time plan but a cycle of continuous rehearsal and refinement.	(Nerwal and Abdelhamid 2012)

This study is subject to two main limitations. First, it relies on the Scopus database and English-only filtering, which may have excluded relevant contributions, such as regional scholarship not indexed in Scopus. Second, the conceptual nature of the bibliometric co-word analysis identifies thematic structures but does not establish causal mechanisms or assess operational performance impacts. Therefore, the proposed definition of Crew Choreography

should be understood as a conceptual synthesis rather than empirical evidence of improvements in productivity, flow, or reliability.

Future research should focus on operationalizing Crew Choreography and testing it within Lean project environments. Key priorities include: (a) conducting empirical case studies on projects implementing the Last Planner System (LPS) and/or takt planning to observe Crew Choreography during handoffs, flow disruptions, and replanning cycles; (b) developing measurable indicators of crew-level synchronization, such as handoff reliability, interruptions, rework triggers, flow stability, and PPC or reasons for variance; and (c) validating these dynamics computationally through agent-based modelling or system dynamics to simulate intra-crew coordination under variability and constraints.

In conclusion, Crew Choreography is an emerging topic with significant potential for advancing Lean Construction. By fostering more efficient and coordinated construction operations, this concept offers a promising avenue for researchers and practitioners seeking to innovate and improve industry practices.

Appendix

The appendix below details the Scopus search strings used in the data collection (Step 1) of our process.

Crew Design: TITLE-ABS-KEY (("Crew Design" OR "Team Design") AND "Construction") AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "ch")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final"))

Crew Planning: TITLE-ABS-KEY ("Crew Planning" OR "Team Planning") AND (EXCLUDE (PREFNAMEAUID , "undefined")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (PUBSTAGE , "final"))

Work Structuring: TITLE-ABS-KEY ("work structuring") AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch")) AND (LIMIT-TO (PUBSTAGE , "final"))

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