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Awareness, Understanding, and Use of Lean Construction in the Norwegian Construction Industry

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Abstract

Question: What is the level of awareness, understanding, and use of Lean Construction in the Norwegian construction industry?

Purpose: This paper aims to fill a gap in the literature by conducting a quantitative survey to investigate the awareness, understanding, and use of Lean Construction (LC) among Norwegian AEC practitioners. It builds on previous studies by providing a broader industry perspective and identifying potential knowledge gaps and barriers to effective LC adoption in Norway.

Research Method: A digital survey with a purposive sample of 94 practitioners was used for this research.

Limitations: The survey responses were primarily from the clients' perspectives.

Implications: The survey reveals that Lean Construction (LC) and collaborative project delivery methods are still in the early adoption stages in Norway, with limited knowledge and application among practitioners. Emphasis on value is lacking compared to cost, time, and quality, indicating a need for greater awareness and integration of value-driven approaches.

Value for practitioners: The survey data highlights current challenges for advancing LC practices both in Norway and globally, guiding future studies to address these gaps and promote more effective LC implementation.

Keywords: Lean Construction, culture, use, awareness, understanding, survey

Paper type: Full paper.

Introduction

The Lean Construction (LC) philosophy emphasizes value generation, securing flow, and removing all non-value-adding activities (waste) (Koskela et al., 2007). In response to the increased complexity and uncertainty in projects, collaborative project delivery

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methods are increasingly used in the industry (Hosseini et al., 2017). Interdisciplinary collaboration is essential to the LC approach (Tzortzopoulos, dos Santos Hentschke, et al., 2020). Recent research has established a growing consensus that collaboration-based relational or integrated Project Delivery Methods (PDMs) handle complexity and uncertainty better than traditional transactional contracts (Walker & Rowlinson, 2019). The emergence of the Lean Construction philosophy in the construction industry was a vital factor in developing integrated delivery methods. For instance, the first Integrated Project Delivery (IPD) contract was developed as a contracting model to support Lean project delivery (Lichtig, 2005). Target Value Delivery (TVD) is another concept introduced through the idea of relational contracts (Ballard, 2020). Evidently, the LC philosophy is closely tied to the emerging trend of using collaborative approaches in the construction industry.

A systematic review from Lohne et al. (2021) examines the rise and impact of Lean Construction in the Norwegian AEC industry and found indications that the adoption of LC in Norway relies on active promoters who are convinced about the benefits of LC. They present a timeline of the introduction of LC in Norwegian academia and its connection from academic circles to the industry. However, the research is based on the contributions from 21 handpicked Lean "champions," and LC positivity bias was mentioned by the authors as a potential limitation of the study. Thus, feedback from more neutral industry practitioners is missing in the literature about Lean Construction's position in Norway. This paper seeks to fill that gap by conducting a quantitative survey investigating the Lean Construction state-of-the-art among Norwegian Architecture, Engineering, and Construction (AEC) practitioners. This will add to the descriptive data collection from Lohne et al. (2021) by providing new data on the LC philosophy from the industrial perspective.

Albalkhy and Sweis (2021) did a systematic literature review with a global perspective, addressing the obstructions to adopting Lean Construction. One barrier they found was a lack of adequate lean *awareness* and *understanding*. A suggested reason for this challenge is that the LC concept is still in its infancy. This paper addresses this barrier by gathering knowledge about how people with real experience in the Norwegian construction industry understand Lean Construction and whether LC principles are applied in Norwegian construction projects. This can reveal gaps in knowledge among practitioners, which can be used to suggest measures to ensure a more effective adoption of LC. A literature review is provided to understand the LC philosophy, its application, and what it seeks to improve by exploring existing research and the theoretical frameworks behind Lean Construction principles.

A survey was conducted with almost 100 practitioners in Norway. The survey assessed industry practitioners' knowledge of Lean Construction principles and practices. Results from the survey are presented and discussed to answer the following research question:

What is the level of awareness, understanding, and use of Lean Construction in the Norwegian construction industry?

The paper is structured with research design and methodology first. Then, the literature review sets the research in the appropriate context by presenting ideas promoted in the LC literature for addressing industry challenges. Next, survey results are presented and discussed in light of these promoted ideas. The concluding section provides final remarks.

Research design and methodology

Research design

According to Koskela, Ferrantelli, et al. (2019), epistemology, the theory of knowledge, has two major starting points – Platonism and Aristotelianism – with the Aristotelian approach being grounded in observations made on the world and the induction of new knowledge based on them. Losee (2001) contends that Aristotle saw scientific inquiry as a cycle from observations to *general principles* and back again through an inductive-deductive method. According to Aristotle, scientific inquiry should be derived from explanatory principles from the phenomena in focus, and then conclusions should be drawn on those phenomena based on these general principles. In this paper, we make use of the Aristotelian approach for research design by following these steps:

1. **Observation** – We have observed that Lean Construction is a methodology used in the construction industry, but there seems to be variation in how well it is understood and used.
2. **Induction** – From these observations, we form a *general principle*: the knowledge of Lean Construction in the construction industry can be improved by mapping and analyzing the current level of use, awareness, and understanding.
3. **Deduction** – Based on this general principle, a survey was developed to measure the knowledge of Lean Construction among construction industry practitioners. By comparing survey results with existing literature, we aimed to highlight specific areas where understanding and awareness were lacking.
4. **Observation** – We conducted the survey and analyzed the results to identify gaps in LC knowledge among construction industry practitioners. We observed how well the practitioners' idea of LC resonated with the LC principles described in the literature.
5. **Conclusion** – The survey findings were used to refine the understanding of how Lean Construction is perceived in the industry. This information will help develop strategies to improve knowledge of Lean Construction in the future.

Literature review

The survey was developed based on a broad range of literature accumulated during years of research. Over the years, numerous tools, techniques, and concepts have emerged within Lean Construction. Therefore, it was imperative to narrow the scope of this study. Selecting which tools, techniques, and concepts to dive into from a large pool of alternatives for this research was challenging. Ultimately, the selection was based on two sources: *Lean Construction: Core Concepts and New Frontiers* from Tzortzopoulos, Kagioglou, et al. (2020) and the *Lean Construction 101* initiative from the Lean Construction Blog (2024). The former, a comprehensive book, collates and organizes research by leading figures in the Lean Construction community, covering key thematic areas of Lean Construction. The latter, an educational initiative by the Lean Construction Blog, aims to educate the most essential themes within Lean Construction to a wider audience beyond academic circles. The Lean Construction Blog is not a source for the literature review in this paper, but it played a crucial role in selecting appropriate tools and concepts for the research. The blog's emphasis on educating a non-academic audience offered valuable perspectives for our selection process.

Early seminal works by Lean Construction pioneers Koskela (1992) and Ballard (1993) were important for understanding the origins and conceptualization of Lean from production to construction. The book from Tzortzopoulos, Kagioglou, et al. (2020) was vital, providing a comprehensive and up-to-date collection of the most important aspects. Additionally, this paper's authors each attended the annual conference of The International Group for Lean Construction (IGLC) several times. This helped give us tacit knowledge about LC and an idea of the primary specialization area within LC from the different people in the LC community. After determining the scope, each selected thematic area's original or reliable sources were sought to describe each concept or tool's foundational intention and premise. In addition, more current research (i.e., research published after 2017) was included to cover any updates that have emerged over the years. These exercises were either done by snowballing the suitable chapters in the book from Tzortzopoulos, Kagioglou, et al. (2020) or by searching for relevant research in Google Scholar or Scopus with search strings matching the specific tool or concept (e.g., “Target Value Delivery,” “A3 reporting,” or “Choosing by Advantages”). In some instances, it was also necessary to add words such as “Lean Construction,” “Lean,” “project management,” or “construction” in the search strings to obtain relevant search output.

Survey

The quality of survey data depends on the sample’s size and representativeness, the data collection methods used, and how well the questions measure what they are intended to (Fowler Jr & Cosenza, 2009). To understand the supposed trend shift in the Norwegian construction industry, the survey was centered around questions about how people in the construction industry related to emerging terms, strategies, and tools, emphasizing Lean Construction. Consequently, industry practitioners were invited to share their insights and experiences.

The main author designed the survey. The survey was discussed and improved in several rounds with two co-authors with substantial experience in construction projects and academic research. Each survey question was described in a local document with a rationale for the research and its theoretical origin. This was done to ensure that every question was justified for the purpose of this research and so the findings could build on existing literature. These exercises made the survey more to the point and cut out unnecessary questions.

The essence of a survey is to gather information about a whole population. However, surveying entire populations is typically impractical due to their size, and sampling methods are often used. These methods are designed to provide reliable data so accurate conclusions can be made with a certain level of confidence (Fellows & Liu, 2021). The construction industry is enormous and has many participants with different work areas. According to Statistics Norway (2024), almost 275,000 people worked in the Norwegian construction industry in 2022. To get an acceptable amount of feedback from the whole collective industry would be highly challenging, if not impossible. Thus, it was necessary to delineate the population to a representative sample that aligned with the research purpose. Purposive sampling was used in this study. Purposive sampling (also known as judgmental sampling) targets respondents who are expected to offer the most relevant and valuable insights, making efficient use of limited research resources (Campbell et al., 2020). According to Taherdoost (2016), the strengths of purposeful sampling are that it is low-cost, convenient, not time-consuming, and ideal for exploratory research design. The weaknesses are that it is somewhat subjective and does not allow for generalization. In purposive sampling, the sampling frame is decided by the knowledge and expertise of the people deciding the sample (Westfall, 2009). It was, therefore, decided to target a population sample with industry practitioners the authors thought to be at the forefront of new developments in the Norwegian construction industry through their role and interest in new developments. The reasoning for this viewpoint was that this sampling frame would be more likely to understand and be aware of Lean Construction compared to people in the industry with less involvement or interest in such developments. Still, the selected sampling frame was subjectively based on expert evaluations by the authors. Such subjective sampling can always involve some bias (Fellows & Liu, 2021), which must be recognized and considered a potential limitation of this study.

It was decided to present the survey at a large project management conference with approximately 175 participants from all project actors, including clients, contractors, technical advisors, architects, lawyers, etc. One important factor when deciding to use the conference as an arena for spreading the survey was that using wide-spreading channels, such as LinkedIn, would result in losing control over who responded. Since the survey was answered anonymously, there was a risk that people outside the sampling frame would answer, which would have negatively affected the validity of the survey results. Additionally, the conference has a strong position in the industry as an arena for knowledge and experience sharing between academia and industry, so it is known that many of the people who follow the new trends in the industry usually participate.

Fellows and Liu (2021) argue that surveys should be piloted and completed by a small sample of respondents to notice any gaps and test whether the questions are unambiguous, easy to answer, understandable, etc. Thus, before the conference, the survey was tested on nine colleagues to check if everything was understandable and in order.

At the conference, the main author was provided with a stand where the survey was presented along with a QR code with a link directly to the survey. Additionally, two colleagues helped spread the survey in two project streams. The QR code was also shared with participants through small talk and mingling. As a way to motivate people, each unique contribution would give a small donation to a charity organization. Additionally, the positive effects of the survey on the industry were explained in a document that was attached to the survey invitation.

Despite all these efforts, only nine people responded on the conference day. A few more answers arrived in the coming days, but another effort was needed to get a decent number of answers to get a reliable data set. The aim was to get around 100 responses. The authors decided to ask 30 relevant practitioners associated with organizations that participated in the project conference. These people forwarded the survey to people they perceived relevant within their organization to keep it within the target frame. After this, the answers started piling up. Especially three arenas proved effective for data gathering:

- A workshop organized by a municipal infrastructure company working with construction and maintenance for collective traffic, consisting of about 60 people. The workshop was mostly attended by project managers and planners from the hosting company. However, people from outside the organization, primarily consultants, also attended.

- A network for knowledge sharing about partnering approaches, organized internally by a contractor company, consisted of about 300 people who were presented with the survey at a workshop.
- Earlier participants in the Norwegian Virtual Design and Construction (VDC) Certificate Programme consisted of about 500 people who received the survey by e-mail.

After these efforts, the total number of respondents rose to 94, which was considered sufficiently close to the goal of 100 responses. By summarizing the different methods for sharing the survey, it is estimated that approximately 1500 people were given the chance to respond. This gives a response rate of about six percent. However, it is not uncommon to achieve a low response rate for surveys conducted via the Internet (Fellows & Liu, 2021). We summarize the survey process by following the sampling process described by Taherdoost (2016):

1. **Clearly define the target population**: The Norwegian construction industry.
2. **Select sampling frame**: Practitioners with roles in project management with a vested interest or investment in following the recent trends in the industry.
3. **Sampling technique**: Purposeful sampling.
4. **Collect data**: Targeted key conferences, workshops, and persons in the industry. Shared the survey individually through presentations and e-mail.
5. **Assess response rate**: 94 respondents and a response rate of about six percent.

Lean Construction - theory and performance indicators

This section will explore existing research and theoretical frameworks related to Lean Construction principles, concepts, and tools to explain what LC is and what it is trying to improve in the realms of project management.

Project stage models

Projects are usually divided into stages with different characteristics, such as uncertainty or influence. According to the Project Management Institute (PMI), all projects generally go through initiation, planning, execution, and closing (PMI, 2017). There are various models of how construction projects are developed in phases and stages (Shabani et al., 2023). In this paper, we will stick to the model provided by Morris (2013), which includes the following stages:

- **Concept** – This is the early front-end phase of a project, where the initial ideas are formed, and suitable concepts are suggested.
- **Feasibility** – Identifying and choosing the most appropriate concept that is aligned with the corporate strategy and objectives and with the highest expected value.
- **Definition** – Planning, specification, and detailed design of the project.
- **Execution** – The project plan is finally completed in the execution stage.
- **Operation** – After the project is handed over, the last stage of a project's life cycle is operation and maintenance.

Transactional vs. Relational Project Delivery Methods

Miller et al. (2000, p. 59) define a Project Delivery Method (PDM) as "a system for organizing and financing design, construction, operations and maintenance activities and facilitates the delivery of a good or service." There are various ways to construct a PDM. Engebø et al. (2020) differentiate between *traditional* and *relation-based* PDMs. Traditional PDMs are described as transactional-based with separate design and delivery. Relation-based PDMs are described as methods with some degree of team integration in both design and construction.

IPD is a relational contracting model often discussed in connection with Lean Construction after it was introduced by Matthews and Howell (2005) and through the work of Sutter Health at the start of the millennium (Lichtig, 2005). For the purpose of this paper, it is imperative to illustrate how this type of contracting differs from the transactional contracting models that have traditionally been used. Olsson (2015) presented a spectrum that illustrates differences between purely transactional and purely relational PDMs and everything in between (see Figure 1). The four top arrows illustrate typical characteristic differences in the continuum between transactional and relational. The bottom arrow suggests which factors make a higher level of collaboration important in terms of size, complexity, uncertainty, and strategic importance. If these factors are low, the necessity for a relational PDM decreases.

Figure 1: A spectrum of project orientation, ranging from transactional to relational (based on Olsson (2015)).

Each PDM represents different levels of collaboration and integration. Lloyd-Walker and Walker (2015) distinguish between three forms of project procurement:

- Traditional (segregated design and delivery), e.g., Design-Bid-Build (DBB).
- Integration of design and delivery (emphasis on planning and control), e.g., Public-Private-Partnership (PPP).
- Integration of project design and delivery teams (emphasis on collaboration and coordination), e.g., Partnering, Alliance, and Integrated Project Delivery.

Kraakenes et al. (2019) investigated Norwegian Design-Build (DB) and partnering projects and found that the five big ideas in Lean Construction resonate well with partnering, while there is less alignment with the DB approach. Engebø (2022) found that contractual elements do not guarantee collaboration, and collaboration does not happen automatically by utilizing only the correct contractual components. He argues that the components must be implemented intentionally as mediators of intentional collaboration.

Further, he argues that collaborative elements range from technical to socially determined. The contractual (technical) determination to collaborate is the first step, but it is also necessary to establish a collaborative organization and a socially determined collaboration culture. Lean Construction represents a philosophy about creating a collaborative culture for value generation and waste reduction (Bertelsen, 2001). However, Lean is not just about implementing strategies to minimize waste but about embracing a deeper organizational culture of continuous improvement and problem-solving (Tapase, 2019).

Exploring the Lean Construction Principles

The Lean philosophy has its roots in the Japanese Toyota Production System (TPS) and was first conceptualized for construction after Koskela (1992) introduced his Transformation-Flow-Value Generation (TFV) theory, a production philosophy for construction that triggered the Lean Construction movement (Tzortzopoulos, Kagioglou, et al., 2020). Mossman (2018) addressed that a clear and unified definition of Lean Construction is still lacking, a discussion beyond this paper's scope. This paper defines Lean Construction as *"the dynamic application of Lean principles, methods, and tools tailored to the unique challenges and contexts of the construction industry."* This definition is inspired by discussions from Koskela (2020) in *Lean Construction: Core Concepts and New Frontiers* (Tzortzopoulos, Kagioglou, et al., 2020), and will be embraced for this study.

Several efforts have been made to systemize the fundamental components of Lean Construction with different labels, whether they are called principles, tenets, ideas, philosophy, or similar. Skaar (2019) emphasizes Lean principles as guiding rules essential to every Lean practitioner. This section presents some of the most prominent principles to illustrate the essence of the Lean Construction philosophy.

The Five Principles of Lean Thinking

One of the first identified tasks of the conceptualization of LC was to explain the theory of Lean Production in the context of construction (Howell & Ballard, 1994). Thus, having a Lean mindset can be considered an essential component. Womack and Jones (1997), pioneers of *Lean Production*, summarized *Lean thinking* with five essential principles:

- **Identify Value** – Clearly define the value provided by each product.
- **Value Stream Mapping** – Identify the value stream associated with each product.
- **Flow** – Ensure uninterrupted flow of value throughout the process.
- **Pull** – Let customers pull value from the producer.
- **Perfection** – Strive for perfection in all aspects of the operation.

When understood together as a continuous iterative process, these principles provide a solid foundation for lean techniques. Later, the five steps were simplified into three (Womack et al., 2007):

- **Purpose** – Correctly specify the customer value your organization is going to deliver.
- **Process** – Focus on the value stream to achieve the objective.
- **People** – Make people responsible for each value stream.

These principles highlight some of the most important aspects of a Lean mindset, which is vital for any Lean organization.

The Transformation-Flow-Value theory

With the TFV theory, Koskela (2000) presented transformation, flow, and value generation as three pillars of production, aiming to create a theoretical foundation for productivity in construction that was lacking. The transformation (T) concept of production involves the alteration of resources, such as workers and machinery, to yield new resources (Grubbström, 1995). The flow (F) concept focuses on waste reduction, the movement of material throughout the project, and the project's overall development (Koskela & Kagioglou, 2006). The value generation concept of production emphasizes a customer-centric approach, with attention to designing products that align with customer requirements (Koskela et al., 2007). The value generation concept can be approached as value added by the transformation (T) or the value generated through client-supplier interaction (V) (Gomes Miron et al., 2015).

The Five Big Ideas

Lean Project Consulting, Inc. presented the "Five Big Ideas that are Reshaping the Design and Delivery of Capital Projects" at a Sutter Health conference in 2004. The Five Big Ideas can be considered a foundation for creating a lean organizational culture through innovative approaches (Lichtig, 2005). These form the framework of Sutter Health's successful Lean project delivery and include the following five ideas (Macomber, 2004):

1. **Collaborate, really collaborate throughout design, planning, and execution** – Design choices require participation from a wide range of project performers. Collaboration in design, planning, and execution contributes positively to design iterations. According to Schöttle et al. (2018), *collaboration* is developed to reach a shared objective and is based on a jointly cultivated project culture grounded in trust and transparency.
2. **Optimize the whole** – Optimizing one activity shall not conflict with other activities in the project. When people push for productivity at subcontract levels, local performance at the task level might be enhanced at the expense of overall performance. Therefore, you must prioritize the project as a whole, not the pieces. Holistic optimization will increase work predictability, reduce project duration, foster better coordination, increase trust, and mitigate rework and delays.
3. **Tightly couple learning with action** – Secure continuous improvement. Avoid large batches and work with a single-piece flow using a PDCA approach (see section 3.5.1) so you can learn from every action. Potential ways to employ this idea include a Plus-Delta review at the end of each planning meeting, 5 Whys (see section 3.5.3) for anything that needs rework, repair, or replacement, or having a five-minute meeting at the end of the to report the daily work with the Last Planners® (see section 3.4.1) on the project.
4. **Projects are single-purpose networks of commitments** – Project management involves creating and managing unique networks of commitments tailored to reach specific project goals. There is a mutual dependence between the project members; making projects are about promises – often substantial ones – or

collections of promises, all bound together by commitments. Using *reliable promises* is a potential action to activate the network of commitments. A promise is considered reliable when a performer has sufficient resources, can assess the time it takes to perform, and takes responsibility for a task (Howell & Macomber, 2002). The Last Planner System® (see section 3.4.1) can continuously control reliable promises.

5. **Intentionally build relationships on projects** – Enhance project relations by establishing trust, openness, a culture of innovation, and a commitment to learning. Ongoing learning, innovation, and collaboration are essential for success in complex and enduring projects. This requires relationships built on trust, respect, appreciation, and mutual care. Building friendships among project team members accelerates project success. A prime example of building relationships between project members has been recorded outside construction, with the Norwegian football team Rosenborg, who achieved enormous success in the 1990s with this principle at the core of their philosophy (Malvik, 2022).

Six Tenets of Lean

The Lean Construction Institute (2024) has introduced what it refers to as the "Six Tenets" or "Six Principles" of Lean, specifically designed for the AEC industry. These principles are meant to structure projects for collective success rather than success for individual project members.

1. **Respect for people -** At the core of the LCI principles are respect and trust in your co-workers. People should be considered human beings, not project assets, and it is important to recognize each team member and foster a culture of openness where everyone feels comfortable.
2. **Optimize the whole -** LCI encourages project members to embrace collaborative work practices that enhance the process toward mutual success instead of optimizing their own part and moving on. For example, acknowledge how your work affects other parts of the project.
3. **Eliminate waste** – Waste is everything non-value-adding. Formoso et al. (2020) studied waste in a construction context and distinguished between "core waste," which is any waste where the activity is both a waste in itself and a cause of other waste, and "lead waste," which is considered a core waste with substantial negative impact. He identified five lead wastes: 1) Making-do, 2) Work-in-progress, 3) Unfinished work, 4) Transportation, and 5) Quality deviations.
4. **Focus on flow -** Attention is paid to process flow across all activities in the project. Workflow is continuously adjusted and aimed at reaching the end objective. Facilitating communication and holding project members responsible through promises ensures harmony and a trusting environment for the people in the project.
5. **Generate value -** All activities that add value to reach project objectives and the value the project is intended to create. Think about continuous improvement and look for opportunities and innovation to benefit the end purpose.
6. **Continuous improvement** – Identify constraints and other potential wastes and address them by implementing the PDCA cycle (see section 3.5.1). Look for opportunities to improve workflow and performance. Tools, information, material,

manpower, equipment, safety, and space are potential resources or constraints to evaluate. Continuous improvement happens bottom-up with small continuous improvements, in contrast to innovation, which often is larger improvements that also can come from the outside and top-down.

Virtual Design and Construction (VDC)

The three major elements of Virtual Design and Construction are Integrated Concurrent Engineering (ICE), Building Information Modeling (BIM), and Project Production Management (PPM). Kunz and Fischer introduced VDC in 2001 (Kunz & Fischer, 2012). They aimed to create a method that clarifies data for practitioners with diverse perspectives and applications, helping them reach their common business objectives.

Lean and VDC share many characteristics but are often considered separate initiatives (Fosse et al., 2017). Two Norwegian case studies discovered positive synergies when Last Planner System®, BIM, and ICE were combined. Dave et al. (2013) identified four areas where BIM and Lean have positive synergies.

- BIM contributes directly to reaching the Lean goals of reduced waste and increased value.
- BIM enables Lean processes, which indirectly help reduce waste and increase value.
- BIM-enabled auxiliary information systems contribute directly and indirectly to reaching Lean goals.
- The Lean Construction emphasis on predictability, discipline, collaboration, and experimentation facilitates and enhances the use of BIM.

It is outside this paper's scope to discuss whether LC and VDC should be considered shared or separate initiatives. However, it is acknowledged that VDC shares characteristics and purpose with LC. Therefore, BIM and ICE, two concepts that represent LC ideas, are included in the research (see sections 3.5.5 and 3.5.6).

Exploring selected Lean Construction concepts

Sections 3.4 and 3.5 are divided into sub-sections resembling the structure of the survey. As a result of the scope reduction (explained in section 2.1), some notable LC tools, techniques, and concepts were omitted from the survey and, therefore, fall outside the scope of this research. Examples include Plus-Delta reviews, Location-Based Management, Set-Based Design, and Make-Ready Planning.

Five concepts, Last Planner System®, Takt Planning, Target Value Delivery, Choosing By Advantage, and Visual Management, are evaluated in more detail than the other tools and concepts. These are concepts rather than single tools, meaning their implementation requires a holistic approach to function optimally. Selected Lean tools will be explained in section 3.5. This will not include tools associated with the concepts that are explained in this section (e.g., look-ahead planning in the Last Planner System®).

Last Planner System®

Production control was thought to be a missing component in the project management toolkit, primarily focused on *project controls,* which are to set cost and schedule targets aligned with the project scope and monitor the progress toward them

(Ballard & Tommelein, 2021). The Last Planner System® (LPS®) was developed in the early 1990s as a method for project *production control*, where the "Last Planner®" is the last in a chain of planners, each issuing instructions to the next (Ballard, 1993). These instructions guide direct work processes rather than planning processes, intending to steer toward targets. One of the main ideas of LPS® is to do more detailed planning when you get closer to the construction of the tasks. LPS® defines different planning levels, from a main plan, through a phase plan, to a look-ahead plan, and down to a weekly work plan (Ballard, 1993). LPS® identifies steps to follow and wasteful activities to remove for reliable project execution, measured in terms of the *Percent Plan Complete* (PPC) (Ghosh et al., 2019). Ultimately, this facilitates continuous coordination and a network of commitments between responsible agents at every level of a project (Macomber & Howell, 2003).

The idea with LPS® is to increase reliability in plan realization through a control system. This emphasis on plan execution reduces the risk of variability spreading to downstream flows and tasks (Ballard, 2000).

Target Value Delivery

TVD, initially coined as *Target Value Design*, has later been advocated to be referred to as *Target Value Delivery* to encapture the full delivery process and not just the design phase (Ballard, 2020). TVD extends beyond Target Costing by prioritizing value over cost alone (Gomes Miron et al., 2015). TVD includes setting targets and defining an *Allowable* Cost and a *Target Cost (TC)* prior to starting design. Then, the Target Costing is used as a basis for steering when developing solutions and making decisions during design and construction. TVD adoption lowers the probability of cost overruns and decreases the contingency percentage within the project budget compared to projects not employing TVD (Do et al., 2014).

The TVD approach aims to incentivize efforts against wasteful spending beyond the project scope while ensuring that the end product's value is not affected by the hunt for cost reductions. TVD highlights the importance of trust, collaboration, early contractor involvement, cross-disciplinary problem-solving, and transparency in projects (Malvik et al., 2021).

Takt Time Planning

Takt Time Planning (TTP) is a concept originating from manufacturing and is based on the idea of creating a predictable *takt* with resource buffers in the assembly line to ensure flow throughout the system (Hopp & Spearman, 2004). Later, it has been adapted to Lean Construction by Frandson et al. (2013). *Space* is considered by Tommelein (2017) as the sixth essential, often overlooked resource in project management, the other five being *time, money, manpower, machines,* and *materials*. An important distinction between construction and manufacturing is that the work moves to the worker in manufacturing, while in construction, the worker has to move to the work (Frandson et al., 2015). This distinction is important because, in construction TTP, these spaces are referred to as a takt time "zone" where each trade can get their work done according to their planned work sequence during the takt time that is the same for every trade within that zone (Tommelein, 2017). Frandson et al. (2015) suggest that TTP can enhance the Last

Planner System® by improving plan reliability and enabling accurate material and resource flow forecasting across various locations.

Takt Time Planning aims to create a continuous flow throughout production, improving predictability and schedule control.

Choosing By Advantages

Choosing By Advantages (CBA) is a system for sound decision-making. CBA assesses the significance of beneficial differences (advantages) between alternatives (Arroyo, 2020). Suhr (2000, p. 2) based the system upon four principles: 1) decisions should be based on the differences among alternatives, not factors, criteria, categories, etc.; 2) decisions should be based on the importance of advantages; 3) decisions should be based on relevant facts; 4) engineers, architects, leaders, etc. are decision-makers that learn how to use sound methods of decision-making. Arroyo et al. (2012) argue that CBA complements other Lean Construction practices and delivers value to stakeholders while reducing uncertainty in decision-making processes.

CBA fosters collaboration and value generation through a holistic approach to sound decision-making.

Visual Management

An important principle in Lean is to ensure process transparency, thereby rendering the process flow visible and comprehensible to the project stakeholders. This transparency supports employee participation and engagement, facilitating the early detection of deviations (Pedó et al., 2020). Murata et al. (2017) contend that insufficient process transparency is one of the major reasons for waste, quality deviations, and safety violations in construction. Visual Management (VM) is a method for achieving such transparency.

Formoso et al. (2002) write that process transparency involves a production process's capacity to effectively communicate with people, and visual communication enables self-service communication. A visual workplace is equipped with various visual devices, such as signs, signals, and mistake-proofing (poka-yoke) mechanisms to communicate with workers. These workplaces are designed to be self-explanatory, self-ordering, self-regulating, and self-improving (Tezel et al., 2009). According to Murata and Katayama (2013), VM effectively detects and eliminates waste and visualizes its sources.

Visual Management promotes process flow, communication, and quality control.

Exploring general Lean concepts and tools

This section explores tools and concepts that emerged within Lean Production or Toyota Production System and were later introduced to construction (VSM, PDCA, A3, 5 Whys, and 5S), concepts associated with VDC (BIM, ICE, Big Room, and Co-Location), and Target Costing.

Plan-Do-Check-Act

The Plan-Do-Check-Act cycle originates in work by Shewhart (1930). He wrote about achieving *controlled* manufactured products by eliminating quality variability through quality control. In LC theory, this conceptualization of production quality, which also accounts for customer value, has been named the value generation model (Koskela, Tezel, et al., 2019). Shewhart's colleague, Deming, presented a version (the Deming Wheel) at a lecture in Japan in 1950, marking the start of the redefined Japanese PDCA cycle, a vital component of *kaizen* (Moen & Norman, 2006). Kaizen is the Japanese term for continuous improvement and is considered a vital part of the Lean philosophy (Liker, 2004).

The PDCA cycle promotes an iterative learning process and continuous quality improvement.

A3 for problem-solving

A3 reporting is a problem-solving tool used to identify, frame, and act on problems and challenges at all levels in a process (Shook, 2008). Koskela (2015) argues that A3 reporting is effective because the standardized documentation of problem-solving, proposals, and reviews makes it easier for people with different viewpoints to contribute and collaborate. Schwagerman and Ulmer (2013) consider the A3 problem-solving process as a tool for documenting continuous improvement, which can be seen in the context of PDCA. The tool places responsibility on fixing the problem through the ownership-feeling of the author. A typical A3 report includes title, owner/date, background, current conditions, targets, analysis, proposed counter-measures, plan, follow-up (Shook, 2008).

A3 reporting encourages continuous improvement in production and reliable promises and commitment from actors by exploiting the feeling of ownership from the A3 report author.

Five Whys

The Five Whys has its roots in the Toyota Production System and is a problem-solving method aimed at uncovering the root cause by repeatedly asking "Why?" five times in succession (Ohno, 2019). In LC, Five Whys has been suggested as a technique to analyze breakdowns to implement countermeasures as part of the Last Planner System® approach (Ballard & Tommelein, 2021) and for accident investigation (Leino & Helfenstein, 2012). Further, the Five Whys is also a common technique for finding the root cause in the problem analysis section of an A3 report.

5S (Sort-Set in order-Shine-Standardize-Sustain)

5S is a method for organizing the workplace to foster a culture of efficiency, value generation, and elimination of non-value-adding activities (Singh et al., 2014). The five elements of 5S are (Michalska & Szewieczek, 2007; Randhawa & Ahuja, 2017):

- **Seiri (Sort):** Sorting only the necessary tools and materials and keeping them in their appropriate place based on relevance and frequency.
- **Seiton (Set in Order):** Arrange the tools and materials systematically to ensure easy and efficient access.
- **Seiso (Shine):** Keeping the workspace clean and tidy also cleaning the mind.
- **Seiketsu (Standardize):** Maintaining cleanliness and tidiness in the workplace by standardizing to allow for consistency.
- **Shitsuke (Sustain):** Sustain Seiri-Seiton-Seiso-Seiketsu. Maintain standards continuously.

The 5S philosophy was developed in Japan and implemented as part of the Toyota Production System (TPS) as an integral part of quality control (Randhawa & Ahuja, 2017).

However, its origins can be traced back to Ford Motor Company strategies. In *Henry Ford's Lean Vision*, Levinson (2002) explores how the Ford Motor Company influenced the development of the TPS, with Ford's CANDO system – "Cleaning up," "Arranging," "Neatness," "Discipline," and "Ongoing improvement" – serving as an inspiration for the 5S methodology.

5S implementation supports VM efforts and promotes flow, safety, waste reduction, and improved productivity in the workplace (Obulam & Rybkowski, 2021).

Building Information Modeling

Building Information Modeling (BIM) is about communicating project information (Del Savio et al., 2022). In VDC, BIM supports product design and pays attention to the physical elements of the VDC model (Kunz & Fischer, 2020). Originally, BIM was limited to 3D BIM, a visualization of the product to be constructed, including walls, doors, ventilation systems, plumbing systems, etc., a digital three-dimensional twin of the final product. However, BIM has since evolved to include dimensions beyond 3D, encompassing 4D, 5D, 6D, and even 7D BIM, wherein model elements are described with critical characteristics to enhance the overall process. Charef et al. (2018) systematically reviewed the dimensions of BIM. They found that 4D BIM is linked with planning or scheduling, and 5D BIM is linked with cost. Moreover, while some academics and practitioners mentioned safety, 6D is most linked with sustainability and 7D with facility management activities.

Sacks et al. (2010) discovered three Lean principles that they argue are supported by BIM: 1) reduced waste because you get the quality right the first time, 2) reduced production uncertainty, securing better flow, and 3) reduced construction time.

Integrated Concurrent Engineering

Integrated Concurrent Engineering (ICE) is a structured approach to interdisciplinary project collaboration, emphasizing in-person decision-making. A vital component of the method is well-prepared work sessions scheduled at agreed-upon intervals throughout the project period (Hermundsgård, 2018). In ICE sessions, a combination of expert designers, advanced modeling, visualization and analysis tools, and social processes are used to create designs for complex systems (Chachere et al., 2004). ICE application involves the concurrent progress of independent tasks, with project actors coordinating closely to ensure effective collaboration, often carried out at a workspace with modern face-to-face collaboration tools to reduce coordination latency (Del Savio et al., 2022). Often, this involves using a Big Room and BIM models so the actors can effectively share information and interact directly with the models.

The ICE approach fosters collaboration and is an arena for interdisciplinary decision-making.

Co-location

Co-location of teams is a method for shortening response times, limiting waiting times and rework, and improving communication and information flow. It also enhances the flow of tacit knowledge and increases knowledge generated from informal interactions (Dave et al., 2013).

Big Room

The “Big Room” is a form of co-location where detailers are working side-by-side in a Big Room to coordinate and model designs together (Khanzode et al., 2007). A Big Room is normally used for ICE sessions.

Target Costing

Target Costing (TC) originated in Japan in the 1960s, but only in the 1980s did it gain real traction outside Japan. Several efforts from Western companies to adopt TC have resulted in a wide variety of ways in which TC functions in practice (Feil et al., 2004). TC was developed to steer costs toward a cost objective (the *target cost*). It is a practice that wants to make cost a driver for design to incentivize reducing waste and increasing value (Ballard, 2006). TC is associated with the concept of *Value* Engineering, which is about maximizing product attributes while minimizing costs (Feil et al., 2004). TC is a means to value delivery but is limited to the cost aspect of TVD (Ballard, 2020).

Value Stream Mapping

Mapping the value stream is considered one of the five lean thinking principles from Womack et al. (2007). It is also essential for the flow concept of the TFV theory as a technique to identify value-adding and non-value-adding activities (Koskela, 2000). Value Stream Mapping (VMS) is a strategic tool for visualizing and analyzing the entire production process, including material and information flow, to identify areas for improvement and enhance overall efficiency (Singh et al., 2011). By mapping the value stream, you gain a holistic view of the process. Seeing the big picture helps you optimize the whole system rather than just individual processes within the system (Rother & Shook, 2003).

Summary of the LC components included in the research

Table 1 summarizes the principles, concepts, tools, and techniques that have been introduced in the literature section. The principles used in the survey are limited to the Five Big Ideas and the Six Tenets of Lean Construction.

Results

Among the 94 survey participants, the respondents were relatively evenly distributed between building and infrastructure projects. 47 were from building projects, 42 were from road or infrastructure, and four were from other areas (e.g., sports facilities). Thus, the answers are well-balanced between the two major parts of the Norwegian construction industry: buildings and road/infrastructure.

Notably, four-fifths of the respondents represented clients or owners (Figure 2). When the results are analyzed, it must be recognized that such a large portion represents the owner’s or client’s perspective.

Table 1: Summary of Lean and LC principles, concepts, tools, and techniques

Lean Construction Principles	Lean Construction Concepts	General Lean Construction Concepts & Tools
▪ Continuous Improvement ▪ Generation of value ▪ Focus on process and flow ▪ Removal of waste ▪ Respect for people ▪ Optimize the whole ▪ Intentionally build relationships on projects ▪ Projects are single-purpose networks of commitments ▪ Couple learning with action ▪ Collaborate, really collaborate, throughout design, planning and execution	▪ Last Planner System® (LPS®) ▪ Target Value Delivery (TVD) ▪ Takt Planning ▪ Choosing By Advantages (CBA) ▪ Visual Management (VM)	▪ Plan-Do-Check-Act (PDCA) ▪ A3 Problem-Solving ▪ 5 Whys ▪ 5S ▪ Building Information Modeling (BIM) ▪ Integrated Concurrent Engineering (ICE) ▪ Co-Location ▪ Big Room ▪ Target Costing (TC) ▪ Value Stream Mapping (VSM)

The upcoming results section will reflect the components presented in this table.

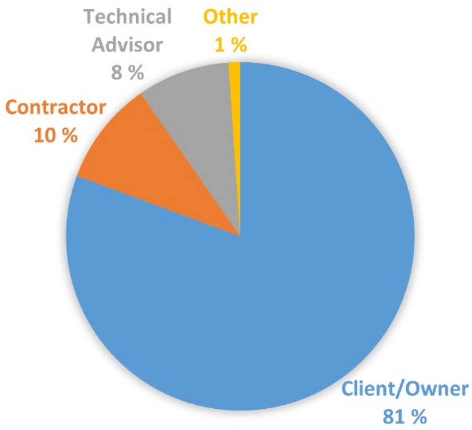

Figure 2: Distribution of participants in the survey.

Figure 3 shows the distribution of project stages the respondents were involved in. The respondents were allowed to pick every stage they were involved in, so they could choose more than one stage. About 80 percent of the respondents were involved in the definition and execution stages, respectively.

When asked which project delivery method they used, the vast majority answered Design-Bid-Build or Design-Build, as illustrated in Figure 4. No participant had used Public-Private Partnership in their last project, and only 13 percent of the respondents answered partnering, alliancing, or IPD. The last five percent did not answer.

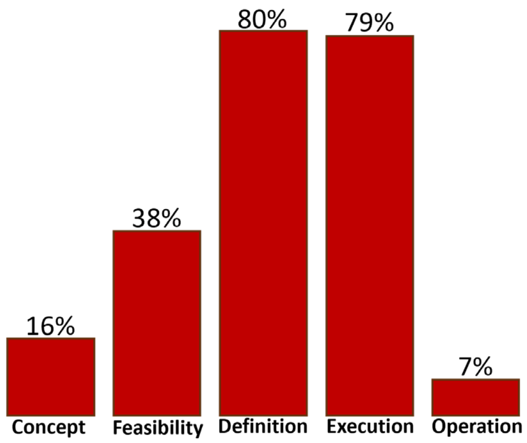

Figure 3: Respondent involvement in each of the project stages.

Inspired by the model from Olsson (2015) (Figure 1), the respondents were asked to answer the level of integration of four elements in their project on an axis from 1 to 10. Figure 4 shows that the average score for each element is relatively far on the left side, well-aligned with what would be expected based on the choice of PDM.

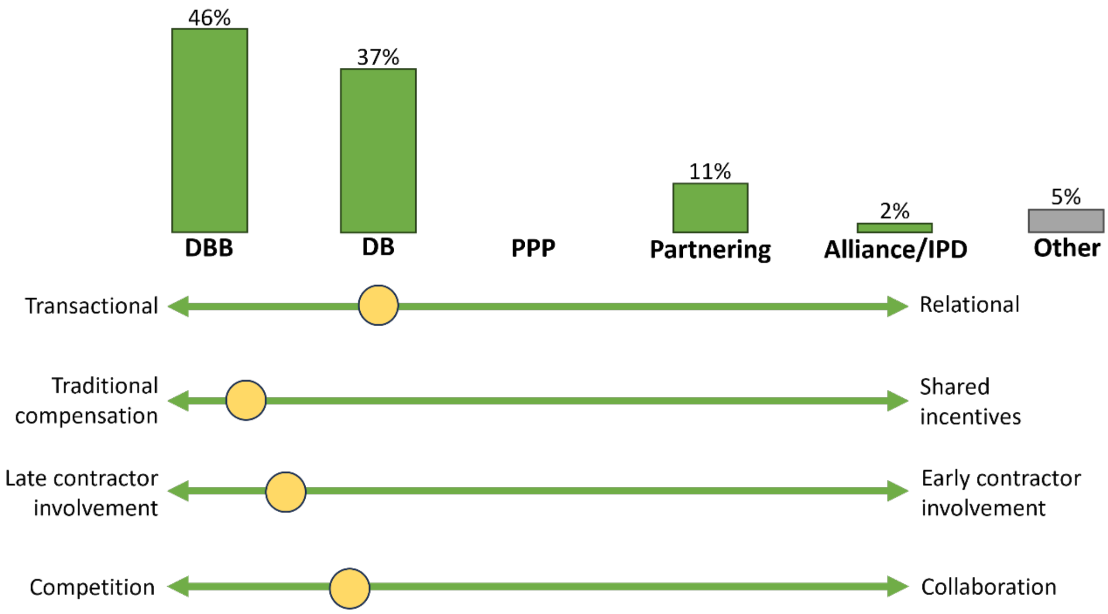

Figure 4: Average level of collaboration in terms of project delivery and distribution of chosen PDM for each respondent.

To evaluate the importance of value compared to the dimensions of the iron triangle, the participants were asked to rank from 1 to 4 what they evaluated as the most important of cost, time, quality, and customer value. Table 2 shows the distribution of the ranking. Half the respondents ranked cost as the most important factor, and the same number of respondents ranked customer value as the least important factor among the four choices. Only 12 percent ranked customer value as the most important factor.

Table 2: Distribution basis for ranking of importance.

	1. choice	2. choice	3. choice	4. choice
Cost	49 %	21 %	18 %	12 %
Time	22 %	37 %	18 %	22 %
Quality	17 %	21 %	45 %	17 %
Customer Value	12 %	20 %	19 %	49 %

Figure 5 illustrates the relative scores of the four factors, showing that project cost was clearly ranked the most important, while customer value was clearly ranked lowest by a margin.

Figure 5: Ranking of importance for cost, time, quality, and customer value.

Lean Construction Principles

Based on the Five Big Ideas and Six Tenets of Lean Construction, each respondent was given a list of 15 different principles and asked to mark every item that characterized their project. The intention was to reveal whether the respondents' projects were characterized by the same principles, regardless of whether their project embrace LC.

Figure 6 illustrates their responses to the factors identified in the Five Big Ideas. The results show that, apart from "collaboration in the execution phase," fewer than half of the respondents adhered to the principles, indicating only a partial inclination toward those highlighted by the Five Big Ideas.

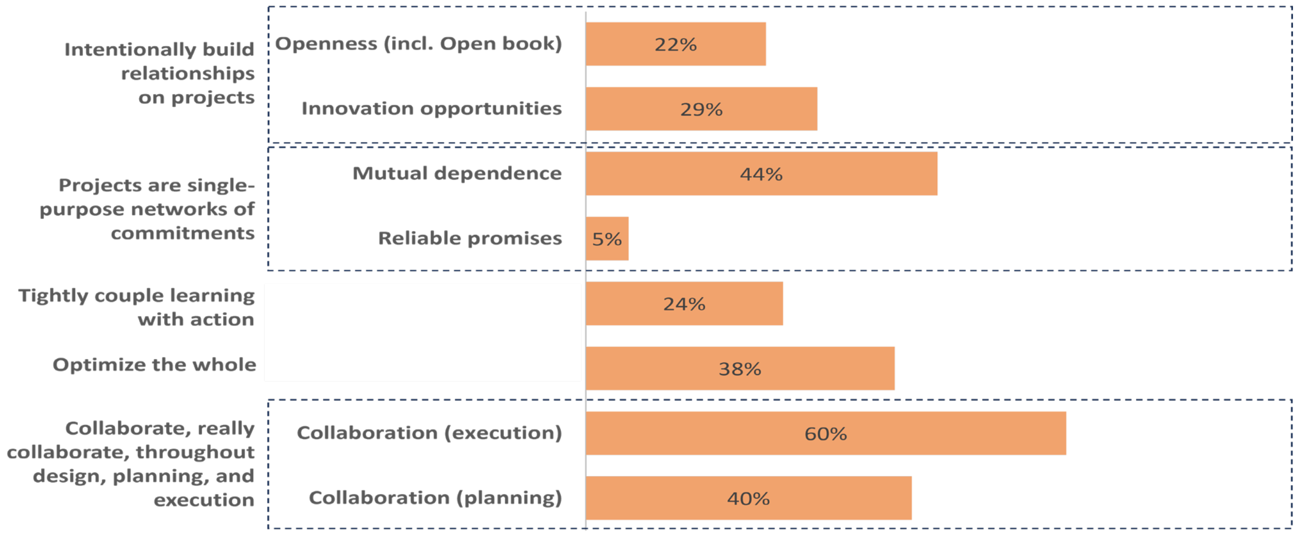

Figure 6: Five Big Ideas of Lean Construction.

On average, the scores for the Six Tenets (Figure 7) were slightly higher than those for the Five Big Ideas. The results indicate that over 50 percent of respondents felt that three of the tenets accurately illustrated how their project was conducted, while each of the six tenets was representative of the projects for more than a third of the respondents.

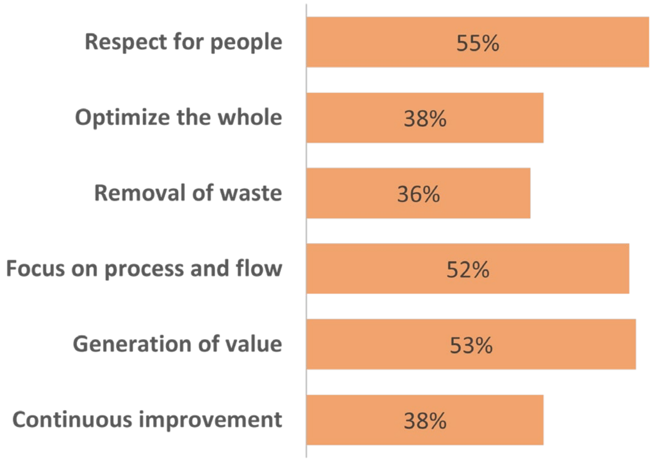

Figure 7: Six Tenets of Lean Construction.

Selected Lean Construction concepts

Each respondent was asked if their project used any of the LC concepts. The percentages are illustrated in Figure 8. The results indicate that the concepts are not widespread in the industry. For instance, as many as 96 percent did not use Choosing By Advantages.

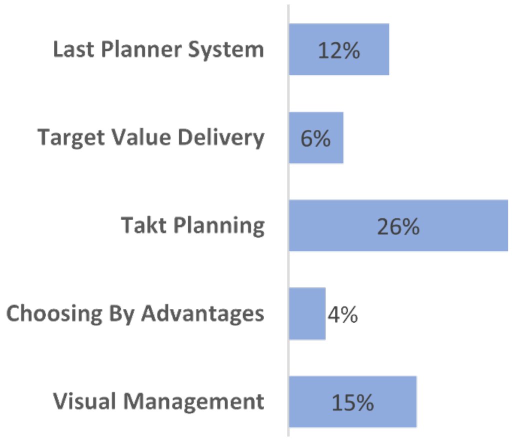

Figure 8: Lean Construction concepts.

Every respondent who answered “yes” got a nested question where they were asked how the concept in question helped handle uncertainty associated with time, cost, quality, and customer value. The idea was to see if their answers harmonized with what the literature says. Unfortunately, the low number of respondents who answered that their project had used the concepts makes it impossible to generalize the results. However, we can still evaluate if there are any clear tendencies in each concept.

Experience with the Last Planner System® (11 respondents) received almost no negative answers and were positive on all factors but most positive on value and progress.

Target Value Delivery (6 respondents) was exclusively positive on all factors but most positive on value and quality. Takt Planning (24 respondents) had positive feedback overall but more variability in the answers, especially regarding costs. Better progress was significantly the most positive aspect of Takt Planning. Choosing By Advantages (4 respondents) did not show any tendencies (primarily because of the low number of respondents). Visual Management (11 respondents) had, like Takt Planning, some variable feedback, especially regarding costs. Better progress and increased quality were the most positive aspects.

Selected general Lean concepts and tools

The survey participants were asked to cross off every general Lean concept or tool that was used in their project from a list. The results are illustrated in Figure 9. Most notably, almost two-thirds of the respondents answered that BIM was used in their projects. However, only half of them said that they used ICE, suggesting that the use of BIM was not necessarily part of a VDC approach. Co-location was also used by about one-third of the respondents, suggesting better prerequisites for collaboration. Apart from these three (somewhat related) tools and concepts, the response is strikingly low for the rest.

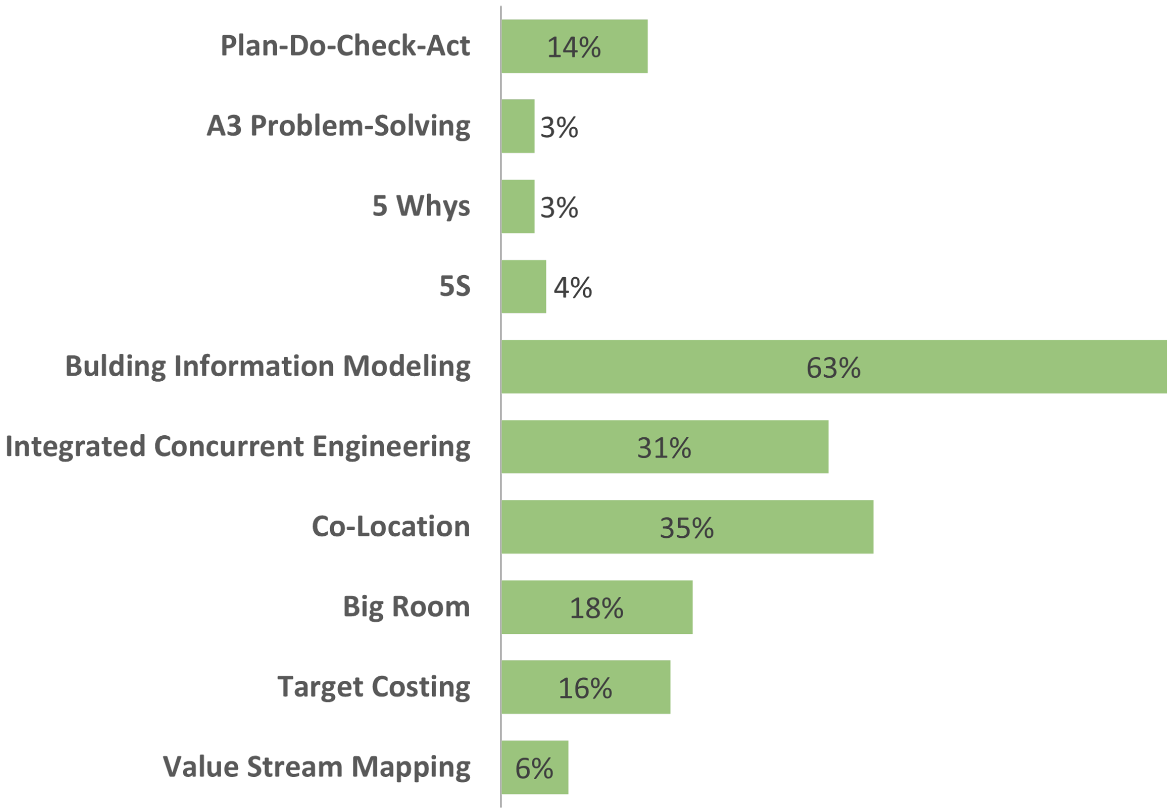

Figure 9: General Lean concepts and tools.

Lean Construction awareness

To map the respondents' awareness of Lean Construction principles, concepts, and tools, they were all asked to write three words they associated with Lean Construction.

However, 30 percent of the participants did not have sufficient knowledge or understanding to answer, and there was a wide variety of answers from the rest. After the survey, the answers were grouped to illustrate the most prominent responses from the participants. Figure 10 shows the most important factors.

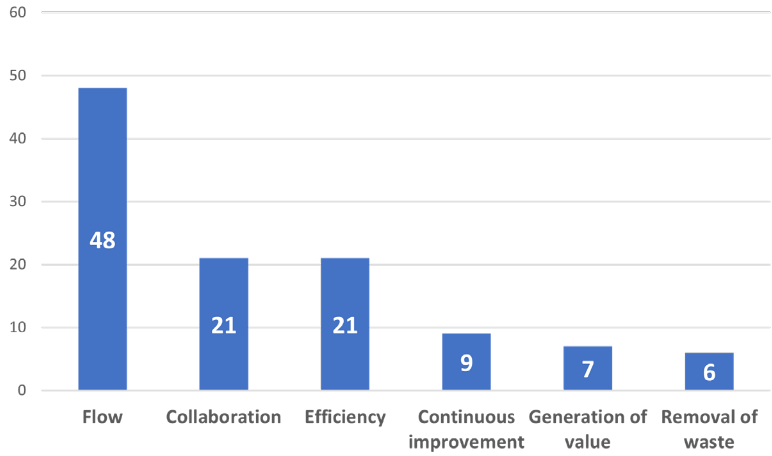

Figure 10: Responses from the participants about what they associated with LC.

Flow was the most prominent response. However, it should be noted that only eight people answered "flow," and the number 48 includes words associated with flow, such as "planning," "Just-In-Time," "structure," "routines," "simultaneity," etc. For collaboration and efficiency, the respondents answered "collaboration"/"cooperation" or "efficiency," respectively. Continuous improvement, value generation, and waste reduction were also highlighted. Additionally, if we relate the answers to the Five Big Ideas and Six Tenets of LC, there were also up to between two and six respondents who had answers that could be tied to either "couple learning with action," "intentionally build relationships on projects," "network of commitments," "optimize the whole," and "respect for people."

As for different Lean Construction-associated tools, there were answers associated with the following:

- 5S
- Agile
- Scrum
- BIM
- Early Contractor Involvement
- IPD
- Last Planner System®
- PDCA
- Quality
- Takt
- VDC
- Visual Management

There were very few responses related to each of these aspects (a maximum of five), but this still illustrates some knowledge about Lean Construction among the practitioners. In addition to all the respondents who did not answer, some answers indicated a limited understanding of LC. 35 responses to this survey question were either:

- Plain misunderstandings, e.g., “less quality focus,”
- Negative attitudes towards LC, e.g., “same shit, new buzzword,”
- Answers that made no sense, e.g., simply “contractor” or “risk,” or
- Simple remarks about LC, e.g., “common sense,” “logical,” and “misunderstood."

Discussion of results

Based on the survey results, it seems like Lean Construction and collaborative project delivery methods are still in their infancy in the Norwegian construction industry. There is evidence that the knowledge and application of Lean Construction is limited. The respondents who answered that they had used LC seemed to understand its benefits. However, this was still only a small portion of the 94 respondents.

Lean Construction Principles

An interesting observation is that the results show that one of the pillars of the LC philosophy, *value*, is less prioritized by respondents compared to the three factors: *time*, *cost*, and *quality*. The results here were convincing, with as many as 50 percent ranking *value* as the least important factor and only 12 percent ranking it as the most important. On the other hand, regarding LC principles outlined in "The Five Big Ideas" and "Six Tenets," a significant portion of respondents, ranging from 5 to 60 percent, stated that these principles characterized their project. This indicates that, while a considerable portion of the respondents leaned toward important LC principles, many did not prioritize *value*, which clearly is misaligned with the LC philosophy. Moreover, 50 percent ranked *cost* as the most important factor, which is more aligned with traditional transaction-based PDMs.

A part of the explanation can be found in the overwhelming proportion of transactional PDMs, suggesting more traditional ways of working. Still, it is important to note that many respondents represented the client and owner, which are the project actors that should be more interested in fulfilling the customer needs (through value generation), especially those involved in the planning stage.

Selected Lean Construction concepts

Only a few respondents had used the selected LC concepts, making it difficult to generalize the results. However, because these respondents represent a sample that actually tried the LC concepts, they reflect industry experience with that particular concept well, allowing us to identify its perceived benefits or limitations.

Table 3 shows how the respondents’ reported benefits (represented by the factors cost, time, quality, and value) correspond to the intention and benefits identified in the literature for each concept.

Overall, the reported benefits from each concept align well with the intentions described in the literature. Although the use of the selected LC concepts is relatively low, respondents who have used them report positive experiences consistent with the intended outcomes of the concepts.

Table 3: Use of concepts and correspondence between intention and reported benefits

Concept	Use (%)	Intention and identified benefits	Reported benefits
LPS®	12	Schedule control, flow, reliable promises, and reduced risk of variability spreading downstream.	Positive on all factors. Especially positive for progress and value.
TVD	6	Incentivizing efforts against wasteful spending beyond the project scope while not compromising value in the hunt for cost reductions.	Positive on all factors. Especially positive for value.
Takt	26	Create a continuous flow throughout production, improving predictability and schedule control.	Very positive on progress.
CBA	4	Collaboration and value generation through a holistic approach to sound decision-making.	N/A.
VM	15	Promotes flow, communication, and quality control.	Variable for cost and value. Positive for progress and quality.

General Lean Construction concepts and tools

The results show that many practitioners have understood that LC is somehow connected to flow or efficiency. A positive note is that a good portion of the LC awareness was tied to either continuous improvement, value generation, or waste reduction. However, variation, ambiguity, non-response, and even hostility to the question of how the respondents understood LC show that there is a lack of awareness of Lean Construction in the Norwegian construction industry. Some important observations among the concepts and tools involve:

- Only six percent of respondents said that their project had used Value Stream Mapping (VSM), suggesting that identifying value-adding and non-value-adding activities has not been central in many projects. Attention to value is arguably one of the most essential objectives of the lean philosophy. While there are indications that some Lean Construction (LC) tools might have been implemented in the Norwegian industry, it seems that there is almost no focus on value. The low number of respondents using VSM aligns with the above-mentioned results regarding LC principles, where cost, time, and quality were clearly prioritized over value.
- 38 percent answered that continuous improvement characterized their project, while only 14 percent said they used Plan-Do-Check-Act. This can be due to calling the process something else or not having a formal method to track or secure improvement.
- 63 percent answered that they used BIM, while only 31 percent used ICE, 18 percent used Big Room, and 35 percent co-location. A significant portion of the respondents have participated in the VDC program, but it seems like most respondents do not utilize the full VDC approach. One reason for this might be

that respondents who didn't participate in these processes were aware of BIM use but lacked knowledge about whether the project used co-location, ICE, or Big Room practices. Nevertheless, the findings suggest that BIM is predominantly employed without fully integrating the collaborative aspects of the process, resulting in a missed opportunity to benefit from interdisciplinary perspectives.

- Six percent answered that they used Target Value Delivery, and 16 percent answered that they used Target Costing. Some confusion between these two concepts was to be expected, but since TVD can be seen as an evolved version of TC, the results make sense. It suggests that efforts to deal with cost are employed, even though TVD is not fully employed.

The results suggest ambiguity for processes and tools. It can be confusing for some that single tools often are part of a bigger concept (e.g., look-ahead planning in LPS®, BIM/ICE in VDC, Target Costing in TVD, etc.). This can be simplified to increase practitioners' understanding and ultimately make LC more constructive in the future.

Conclusion and further work

After describing the LC philosophy and its tools and concepts, a survey based on the literature review guided the answer to the research question, "What is the level of awareness, understanding, and use of Lean Construction in the Norwegian construction industry?"

The survey was conducted with almost 100 practitioners in the Norwegian construction industry. The survey results revealed that LC and collaborative project delivery methods are still in the early stages of adoption within the Norwegian construction industry. Despite LC's potential benefits, respondents' knowledge and application of its principles appear limited. While some practitioners understand LC's advantages, only a few of the surveyed individuals reported using LC methods.

One important observation was that value appeared to be less emphasized than time, cost, and quality. This misalignment with LC philosophy suggests a need for greater awareness and integration of value-driven approaches in construction projects. Furthermore, the results indicate a predominance of traditional transaction-based Project Delivery Methods (PDMs) in the industry, which may hinder the adoption of LC principles. However, it is noteworthy that some respondents expressed familiarity with LC concepts without implementing them in their projects.

The emphasis on value is crucial as it represents a significant challenge within the industry. From the macro level in the concept phase to the execution stage, there is a clear need for better and more consistent understanding and value awareness. Although most respondents are clients or owners, the focus on value remains limited, with only a small percentage utilizing tools like Choosing by Advantages. This highlights a major barrier to adopting more tools from the LC toolbox. Without addressing this issue, further discussions on value delivery are unlikely to be productive.

Overall, the survey highlights the current challenges and opportunities for advancing Lean Construction practices in the Norwegian construction industry. By addressing these challenges and building on them, the industry can move towards more efficient, collaborative, and value-driven project delivery approaches in the future.

Implications for practitioners and researchers

A change process is challenging for everyone involved in construction projects, regardless of position, experience, and background. Therefore, it was essential to include a wide range of opinions, experiences, and viewpoints in the survey to ensure that the results can be used constructively. The survey has created a comprehensive data set on trends related to collaboration in the Norwegian construction industry. The challenges of the change process experienced with the use of LC in Norway are similar to those in other countries where LC is introduced, thus making the results valuable globally. The results have mapped practitioners' (primarily clients) understanding of LC principles, tools, and concepts, including how and if they are used. Further, the research identified the practitioners' prioritization of the four factors: cost, time, quality, and value.

This knowledge about LC awareness and understanding in the industry indicates where the current challenges lie and can thereby be a guide for a more thorough use of Lean Construction methodology.

Limitations and Future Research

Due to the uneven distribution of participants, the study primarily reflects the owner/clients' perspective. A more balanced distribution with additional responses from contractors and technical advisors would strengthen the findings. Interestingly, despite the predominance of owner/client representatives, the results align with what might be expected from a contractor's perspective, with greater emphasis on time and cost over value and quality. Conducting the study with a larger sample of contractors could reveal if this trend becomes more evident. Additionally, applying the survey in another country and comparing the results could provide further insights. Another limitation of the study is the absence of data on the age and experience of the respondents. Including this information in future studies would provide a more comprehensive understanding of respondents' backgrounds and how it might influence their perspectives.

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