

Challenges of Performance Measurement in Lean Construction and the Last Planner System®: A Norwegian Case

Lena E. Bygballe¹, Sanne K. Sand-Holm², Ceyda Pakoglu³ & Fredrik Svalestuen⁴

Abstract

Question: How and why is performance measured in relation to Lean Construction (LC) and the Last Planner System® (LPS®)? What are key challenges thereof, and how might these be overcome?

Purpose: The purpose of this research is to add better understanding of performance measurement in relation to LC and the LPS by addressing key challenges and provide suggestions of how to overcome these.

Research Method: The paper draws upon a qualitative case study of a construction company in Norway and its use of performance measurement in relation to the LPS.

Findings: The findings demonstrate that performance is measured in various ways and to various extents in the case company. They also demonstrate that a more strategic and systematic approach to performance measurement is needed to cope with the challenges of measuring performance and to reap the benefits of LC and the LPS. This includes sensitivity to social conditions related to performance measurement.

Limitations: The paper is based on a single case study in the Norwegian setting, and future studies should seek to build on and refine the findings presented here.

Implications: If performance measurement, both in relation to the LPS and more generally to LC is not sensitive to social issues, it might lead to avoidance and neglect at best, and opportunism and abuse at worst.

Value for practitioners: The paper addresses key issues and challenges involved in performance measurement in relation to LC and the LPS, and how practitioners might reap the benefits and avoid pitfalls associated with performance measurement.

Keywords: Performance measurement, Lean Construction, Last Planner System®, challenges, conditions

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¹ PhD, Associate professor and leader of Centre for the Construction Industry, BI Norwegian Business School, +47 46410459, lena.bygballe@bi.no

² MSc, Business consultant, Columbus Norge AS, +47 92272790, sanne.kristin.holm@columbusglobal.com

³ MSc, Business consultant, Sopra Steria Group SA, +47 47679976, ceyda.pakoglu@soprasteria.com

⁴ PhD, Production- and process manager at Veidekke AS, +47 986 73 172, fredrik.svalestuen@veidekke.no

Introduction

Considered as one of the most promising strategies to improve construction productivity and performance, Lean Construction (LC), and more specifically the Last Planner System® (LPS®) (Ballard, 2000), involves performance measurement (Ballard & Tommelein, 2016; Barth, Formoso, & Sterzi, 2019; España, Tsao, & Hauser, 2012; Koskela, 1992; Lantelme & Formoso, 2000). However, even if measurement is considered important in the LC literature, the literature is scarce (Barth et al., 2019) and we lack an explicit discussion about performance measurement and the challenges it presents. The interpretation of lean in construction has arguably given priority to implementing specific tools and concepts rather than the entire business philosophy (Saurin, Rooke, & Koskela, 2013). Similarly, while there are several taxonomies of different metrics related to LC and the LPS, such as the Percent Plan Completed (PPC) (e.g., Barth et al., 2019; España et al., 2012), there is surprisingly little discussion about the use and implementation of performance measurement in this setting. We argue that such a discussion must exceed questions related to what we should/can measure and how, to include the question of why we should measure. This is important to understand potential challenges of performance measurement (Neely, 1999; Neely, Adams, & Kennerley, 2002), and includes considerations to the social aspects of implementation and use of LC concepts (Bygballe, Endresen, & Fållun, 2018; Green & May, 2005; Sage, Dainty, & Brookes, 2012).

In this paper, we aim to add better understanding of challenges of performance measurement related to LC, and more specifically related to the LPS by addressing the following research questions: How and why is performance measured in relation to LC and the LPS? What are key challenges thereof, and how might these be overcome? To answer these questions, we use a qualitative case study of a construction company in Norway, hereafter referred to as ConstructCo for the sake of anonymity. ConstructCo has for the past twenty years sought to implement LC, and more particularly a variant of the LPS, which they call Collaborative Planning (CP).

Our findings demonstrate that performance measurement is a challenge because lack of motivation and belief in it being worthwhile, as well as lack of consensus in the organization at large regarding the value of performance measurement. The findings also show that the lack of a formal and coherent system and knowledge about how to do it in relation to the LPS prevents adoption. These findings allow us to make two areas of contributions to the LC literature. First, we extend the traditional focus on tools and specific metrics to include an overall discussion of the implementation of performance measurement in relation to LC and the LPS. Second, we contribute with detailed empirical insight into the social conditions of performance measurement in relation to the LPS and highlight the importance of addressing the “why” aspect of performance measurement to achieve improvements by LC and the LPS.

In the next section, we review and present literature that we find relevant to the performance measurement discussion. We identify what types of measurements are typical in LC and the LPS, challenges that previous research has identified, and other key aspects of the phenomenon. Thereafter, we describe the methods for the study, including the case and how we have studied it. The findings are then presented, focusing on what, how, and why LPS elements are measured in the case, and the perceived challenges thereof. Finally,

we discuss the findings and conclude with key theoretical and practical implications and suggestions for future research.

Theoretical basis

Lean Construction, the Last Planner System® and Performance Measurement

Lean tools, techniques, and concepts, such as the LPS (Ballard, 2000) have been promoted as a key means to improve performance in the construction industry (Ballard, Tommelein, Koskela, & Howell, 2002). Performance measurement is a central issue in this respect and has been addressed in the LC literature in recent years (e.g. Ballard & Tommelein, 2016; Barth et al., 2019). For example, Ballard and Tommelein (2016) argued that measurement is important in the LPS process since it helps identifying gaps between what will be done and what has been done. It is therefore central to learning and overall performance management.

In the general management literature, the understanding of performance measurement is debated, and there is no coherent definition of the concept (Bititci, Garengo, Dörfler, & Nudurupati, 2012). However, according to Neely (1999), performance measurement can be defined as the process of quantifying the effectiveness and efficiency of past actions. Performance measurement, such as the balanced scorecard, is considered a critical management tool that can help to determine failure or success in both functional and organizational performance (Kaplan & Norton, 1996). If used properly, performance measurement helps to create feedback on the effectiveness of improvement interventions, which is critical for organizational development and learning (Kennerley & Neely, 2002). By developing and implementing a balanced set of measures, business performance can be enhanced (Kaplan & Norton, 1996). However, this requires that the performance measurement is aligned with organizational policies, objectives and missions (Neely et al., 2002). For example, even if improvement is the overall purpose of performance measurement, different purposes (e.g., evaluation, budget, promotion, etc.) require a differentiated approach (Behn, 2003). Furthermore, while performance measurement has traditionally been focused on control and adjustments, there are voices arguing that today's complex and turbulent business context requires a system perspective on performance measurement, which focuses on autonomy, learning and improvement (e.g., Bourne, Franco-Santos, Micheli, & Pavlov, 2018).

In the LC literature, performance measurement has primarily been related to the needs for identifying areas for continuous improvements, which is key in LC (Fosse & Ballard, 2016). Without appropriate performance measurement systems, it is challenging for organizations to understand how to achieve improvement in their lean operations or why poor lean performance continues (Leong & Tilley, 2008). Performance measurement also provides the information that is required for obtaining process control and enables the opportunity to develop challenging goals in organizations implementing LC (Lantelme & Formoso, 2000; Moon, Yu, & Kim, 2007).

A central feature of LC is to work towards reducing possible disturbances and obstacles before production takes place (Koskela, 1992). Koskela (2000) identified seven preconditions (and resource flows) for the execution of a construction task: construction

design, components and materials, workers, equipment, space, connecting works, and external conditions. These preconditions are important to reduce waste. Inspired by Koskela (1992, 2000), Kalsaas (2013) argued that there are three key factors that need to be addressed to reduce time and effort in relation to waste. First, there must be a commitment by the management team to improve every activity in the organization; Second, there must be involvement of the employees, where they are able to take responsibility and control their process; Third, there must be a focus on measurable improvements. Kalsaas (2013) concluded that the implementation of such measurements would require much learning.

In addition to measuring waste, both LC and the LPS focus on ensuring predictable production flows (Koskela, Howell, Ballard, & Tommelein, 2002). In terms of performance measurement it is not only about measuring final results but the process as such to evaluate performance in relation to flow and value and to identify the root causes to these potential disturbances (Barth et al., 2019; España et al., 2012). Performance measurement provides valuable information and overview of project progress. It creates a basis for progressive improvement through root-cause analysis, which, in turn, can enhance opportunities for an increase in efficiency and quality. There are several metrics used in relation to LC and the LPS (See, for an overview, Barth et al., 2019; España et al., 2012).

According to Ballard and Tommelein (2016), central performance metrics in the LPS are the PPC, Tasks Made Ready (TMR), and Tasks Anticipated (TA), in addition to Frequency of Plan Failures. However, the authors warn that although PPC could improve labor productivity, a PPC of 100% do not guarantee that the project will not fall behind schedule. Thus, it is argued that PPC should be complemented by other performance metrics (Barth et al., 2019; Hamzeh, El Samad, & Emdanat, 2019). This is in line with scholars in the general literature, who argue that the use of a single factor metric could be misleading, as workers and managers may find it challenging to get the overall picture and will thereby not be able to use it in their decisions and priorities (Chew, 1988). Instead, one should use multiple single-factor metrics and combine them, which makes identifying the underlying causes of changes in productivity much easier (Crawford & Vogl, 2006).

While extant LC literature has demonstrated the merits of LC, the LPS and performance measurements for improving construction performance, the degree of implementation varies in practice (Ballard & Howell, 2003). For example, according to Ballard and Tommelein (2016), one of the least implemented components of LPS is measurement of lookahead planning performance. This recognition brings us over to the challenges of implementation.

Challenges and Implementation Issues

LC scholars have identified several challenges in relation to implementing LC and the LPS, particularly related to how these concepts are interpreted and used in practice (Sage et al., 2012). It is argued that when implementing lean principles in the construction industry, the unique aspects of the industry need to be taken into consideration (Jørgensen & Emmitt, 2008; Koskela, 2000). Furthermore, to ensure successful implementation, the key principles of LC must be accompanied by a consistent strategy for the process of implementation, whereas every actor is actively involved and participate in the activities toward implementing the lean tools and techniques (Mossman, 2009). As Porwal et al.

(2010) stated, the development of LPS implementation strategies and training are important prerequisites for achieving successful implementation and use of the LPS.

However, earlier research has demonstrated that managers in the construction industry tend to rely more on their experience and intuition when it comes to problem solving and decision-making, instead of a structured set of data and tools to understand the problem (Lantelme & Formoso, 2000). A similar tendency yields performance measurement. As Ackoff and Bibb (2006, p. 4) noticed, "Managers, who do not know how to measure what they want, settle for wanting what they can measure." An interesting contribution to this discussion was provided by Andy Neely, who in an interview with Sarah Powell about performance measurement claimed that in the 1990s, there was a tendency to measure things that were easy to measure. This often meant measuring the wrong things. However, this started to change, and the problem throughout the 2000 became too excessive measurement (Powell, 2004). Neely further argued that when designing measurement systems, the challenge lies within choosing the right metrics, and the outcome is often that companies just try to quantify everything. Finally, Neely warned that negative data from performance measurements can often be used in an intimidating and judgmental way by management, which triggers a defensive behavior amongst the employees. Due to people's fear of such negative measurements, the data might consequently end up being inaccurate, or even manipulated, to make sure the targets are seemingly being achieved so that there is no blame to be distributed (Powell, 2004).

Adding to this discussion, Bernstein (2012) argued that even if transparency is, most commonly, a positive thing, if it results in an experience of being programmed and controlled, with detailed behavioral recommendations written in manuals, it will inhibit productivity. Similarly, Smith and Bititci (2017) suggested that employee engagement is influenced by how targets and measures are being used. The consequence of not acknowledging the interplay between formal and informal conditions and employee engagement, in addition to the characteristics of how the process is being managed, may yield unintended or unexpected results (Smith & Bititci, 2017). A similar concern has been raised by LC scholars, urging for the need to not only focus on formal tools and techniques but also on the impact of informal conditions and the social context (Bygballe et al., 2018; Green & May, 2005; Sage et al., 2012). These scholars acknowledge that construction projects are "socio-technical" systems, where the social aspects play an important role, and need to be taken into consideration when implementing LC (Green & May, 2005).

In sum, LC research has provided important insights on how performance is measured in LC and the LPS, and of implementation challenges. Nevertheless, despite this emphasis and insights, we still lack a good understanding of how and why performance is measured in LC and LPS practice. The general literature on performance measurement might provide relevant insight into these issues, such as the focus on how such measurement is perceived and used but we need to connect these to the specific context of construction and the implementation of performance measurement in relation to LC and the LPS.

Methods

This paper draws upon a case study (Yin, 2017) of ConstructCo, a construction company in the Norwegian construction industry. Case studies are useful for examining the complexities and relational aspects of a phenomenon in its context (Dubois & Gadde,

2002). In the construction setting, this means studying phenomena in real life projects, and how project participants make decisions about real issues that impact on key performance indicators (Taylor et al., 2011). These arguments combined with the insight from earlier research formed the basis for choosing a case study design for our research on measuring performance in relation to the LPS and resulting challenges.

Like many other companies in the Norwegian construction industry, ConstructCo has sought to adopt practices and methodologies aimed at improving overall performance. LC is one of these concepts, which has attracted much interest over the past 15 years (Lohne et al., 2021). ConstructCo started their LC journey in the early 2000 and have over the years developed their own concept and methods designed to increase the company's productivity, called Collaborative Planning (CP). This can be viewed as an adapted version of the LPS (Ballard, 2000). In discussions with company representatives, we learned that the use of performance measurement in relation to CP (as well as CP itself) varied across the projects, and it was clear that the overall CP journey had been challenging. As such we found ConstructCo as a suitable case to answer the research question, representing a typical case in the industry while at the same time allowing us to study the complexities of performance measurement in relation to the LPS over a period of time (Yin, 2017).

We have used several data sources, including interviews, documents, site visits and observations in meetings. Triangulating between these different sources provides credibility to the study (Yin, 2017). 17 formal interviews with 18 interviewees (one joint interview) were conducted over a period of one year (June 2018-June 2019), each lasting for approximately one hour. Table 1 shows an overview of the interviews.

Table 1: Overview of formal interviews and interviewees

	<i>Interviewee code</i>
ConstructCo	
<i>Project portfolio/central level managers</i>	#1, 2
<i>Project managers</i>	#3, 4, 5, 6
<i>Construction managers</i>	# 7, 8, 9, 10
<i>Team managers</i>	#11, 12
<i>Other project participants</i>	#13
Other organizations	
<i>Managers from another company</i>	#14, 15
<i>University professors</i>	#16, 17, 18
Total	18 interviewees in 17 interviews

The interviewees came mainly from different housing- and commercial building projects using CP. We also interviewed managers at the central level, who represented key contacts throughout the study. The interviewees had different roles in relation to performance measurement - some being responsible while others being subjects to measurement. The variety of interviewees was crucial to comprehend the different opinions and experiences with CP and performance measurement in the organization at large. Even if we focused on how CP and performance measurement were implemented (or not) on the project level, our key concern and unit of analysis were ConstructCo on the

company level. Therefore, we interviewed people involved across different projects. In addition to ConstructCo representatives, we interviewed representatives from two other construction companies and university professors with experiences and expert knowledge of LC and/or performance measurement. The reason was that we wanted to understand the context in which the case was embedded. The interviews were semi-structured and informed by the literature. The questions centered on what, how, who, and why performance was measured within CP and general aspects of performance measurement. We also accessed a range of company documents, including two guidelines for CP in construction and design respectively and data from projects that had implemented performance measurement as part of CP, such as PPC measurements.

The data were systematized and analyzed in an iterative process where insights from the empirical findings and the literature were systematically combined (Dubois & Gadde, 2002). The data were coded into some aggregated themes informed by the literature, until reaching a good overview of how and why performance measurement was used in combination with CP, the challenges of these efforts, and influencing conditions. Two of the authors conducted the primary data collection and analysis but all authors discussed the interpretations and related these to the focus of the paper. Furthermore, to “meet the burden of proofs” (Taylor et al., 2011), the case description and analysis were reviewed and discussed with company representatives. Table 2 shows the coding scheme.

Table 2: Overview of coding scheme

<i>Aggregated themes</i>	<i>Sub-themes</i>	<i>Extracts from data</i>
How and why CP performance is measured	Control and overview of project progress, improvements, time reduction, sharing experiences, follow-up and sanctioning	Quotations like: “There is nothing as important as to have control on productivity and PPC is quite easy to measure.” “The transparency of how the project is evolving gives us the opportunity to act if necessary.” “If one doesn’t document, how to share the experiences in a reasonable and proper way?” “I used PPC to prioritize which trades to follow-up.” “It is obvious if you want to sanction the subcontractors, the numbers are very useful.”
Key challenges	Lack of system, tools, knowledge and interest/belief in its value, different perceptions	Quotations like: “It is highly important to measure systematically. We measure but we don’t take the evaluations further with us.” “We realize the value of it and are aware of the need but have not figured how to do it yet.” “I’ve not yet found any tools that can measure it [CP performance].” “The PPC measurements do not really interest me.” “It really affects the culture - it will destroy a lot if you have someone who opposes to it.” Observations that results were perceived and attributed differently.
Key conditions	Overall understanding, timing, use	Quotations like: “The numbers have a story to tell, but one has to understand what lies behind them.” “At this stage I don’t think it will be useful, or it is quite limited what you get out of it.” “Measurements should not be used to expose someone, rather it is meant for improving us and how we work.”

Findings

In the following sections, we present how and why performance measurements are used in combination with ConstructCo's Collaborative Planning (CP). Then, we present perceived challenges of performance measurements, including views on key conditions for measurement to work as intended.

Implementing Collaborative Planning in ConstructCo

It has long been recognized in ConstructCo that a continuous focus on reducing the proportion of lost time in the construction production is critical to productivity improvements. Company analyses show that 60% of time spent can be defined as productive time and the remaining 40% as lost time (Company document, 2019). These categories are broken down into execution and planning (direct and indirect labor), and unproductive and counterproductive time (Figure 1).

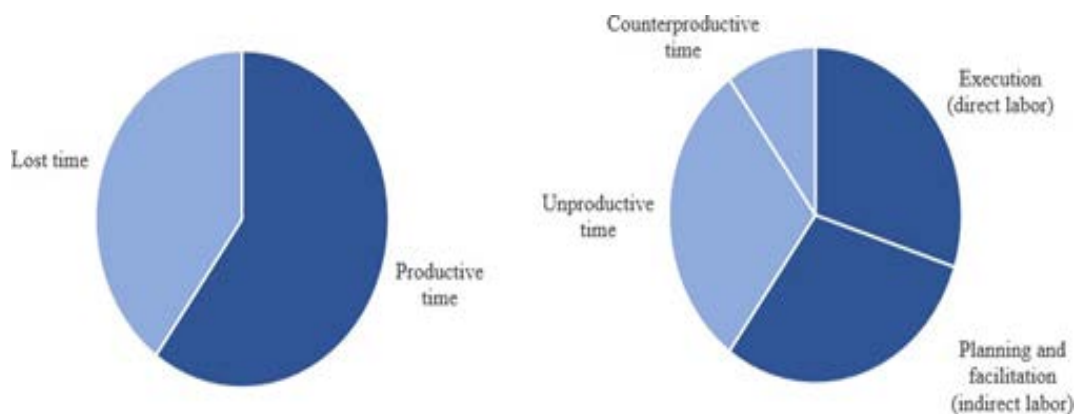


Figure 1: Study of workflow and lost time in production (Company document, 2019)

The focus on productivity and needs for improvement were key drivers for developing CP, which commenced throughout the 2000s in a combined effort between central level managers and local level managers and some projects. The CP includes some overall principles and focuses on involvement:

- All schedules are planned collaboratively by those who will perform the work.
- Everyone knows and have influence of their own work.
- Plan through mutual promises.
- Plan in greater detail as you get closer to doing the work.
- Reveal and remove constraints on planned tasks as a team.
- Use continuous improvement and learn from breakdowns.
- Each plan level has an owner.

The concept also includes a more specific method with key elements, which the company refers to as ConstructCo's adapted version of the LPS. The company learned about the LPS through the international Lean Construction community:

- Division of labor time, which outlines how different management levels (but also including craft workers) are responsible for planning in different time spans.
- A constraint analysis, based on the seven preconditions (Koskela, 2000).

- A planning structure, which outlines the strategic planning process and schedule.
- A meeting structure, which is adapted to the schedules.
- A risk analysis, which focuses on a systematic analysis of risk and elimination of hazards.

Based on the experiences with using CP in some projects, two formal guidelines were developed with the aim of aiding implementation across the project-based organization: First the CP in Production Management (CPP), and later CP in Design Management (CDM). Only the second included explicit measurement, in terms of PPC. Our interviewees pointed out that performance is debated in the industry at large, and measuring it is a challenging endeavor. Nevertheless, most agreed that the productivity can certainly be improved, and that CP is an important means in this respect.

Collaborative Planning and Performance Measurement in Practice

The interviews revealed that there were no formal system or unified practice in the company at large for measuring CP performance. Several of the interviewees argued that the company should develop a shared method for measuring, which could be carried out systematically across the projects. The use of such measurement varied across the projects, as did the knowledge and experiences, and opinions in the company at large. However, most of the interviewees reported that they focused on the seven preconditions (Koskela, 2000) as a basis for the lookahead plan and for ensuring healthy activities and flow efficiency at the construction site. Several of the interviewees argued that a well-developed lookahead plan, based on input from all the trades and aligned with the project plan, is critical throughout the project execution process. Some also noticed that a well prepared lookahead plan makes it easier to do measurements in the weekly work.

A few of the projects systematically used PPC measurement. As some of the representatives from these projects noticed, the more frequently the PPC is registered, the easier and better it is to analyze and interpret the output. For example, in one of the projects, PPC was used to analyze why they were not able to finish a planned activity based on the seven conditions. There were also some interviewees that stated they did not use the traditional LPS metrics, however, later corrected themselves by explaining that: "We kind of measure productivity on the construction site. We have done it without calling it PPC, TA, TMR. We do it by looking into the project status, and make sure that everything is ready for the next work task." (Interviewee #3). Another interviewee explained: "We probably measure more than we can show. There are actually many measurements behind this plan." (Interviewee #4).

In many of the projects, deviations in relation to the seven preconditions were discussed in site meetings. Figure 2 provides an illustration of the reasons for deviations in one project.

Interestingly, when observing a meeting in this project, we discovered that there were different understandings of how to define and attribute the deviations. In this project one of the trades struggled to finish their job due to bad weather conditions. In the follow-up discussion, they would argue that it was due to *external conditions*, which were impossible to control. Others, on the other hand, argued that they should have anticipated it and used a specific fabric to cover the area, thus minimizing the time used

to remove snow and clear the workspace. These people meant that it should be interpreted as failure in *connecting activities*.

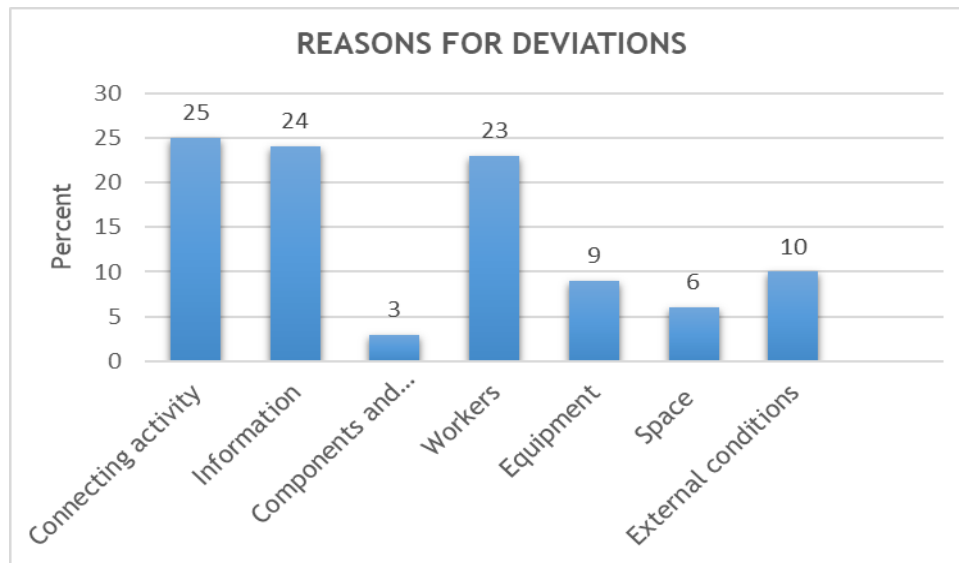


Figure 2: Reasons for deviation

Those who had implemented performance measurement in their project talked about several benefits, particularly the opportunity to gain better control over project progress and to reduce time and create better workflow. In one of the projects, they had managed to reduce the time spent on each apartment by 50%, based on the input from measurements. A key argument for measuring was to get an overview and that the findings and analysis could be a starting point for improvement initiatives for subsequent projects. Some argued that it would also allow for exchanging experience and knowledge between the projects. Several of the interviewees said that they would like a shared experience-database within the company: “[...] where we can bring it with us into the next phase or project.” (Interviewee #10). As another interviewee noticed, “If it is not documented, how could you share experiences and knowledge in a reasonable and proper way.”? (Interviewee #2).

One project manager explained that construction workers were asking for more feedback on their progress on a more general basis. In one of the projects, they had monthly feedback meetings where the project manager did not present the actual PPC measurements but rather a general indication of how the project was performing. Some of the interviewees argued that by measuring performance, the managers gain more time through better time allocation. Some also stated that they used performance metrics to get an indication of which trade is struggling, and thereby could focus their time to follow up on these trades, as well as a basis for sanctioning.

Perceived Challenges and Key Conditions of Measurement

The interviews and observations revealed different views on performance measurement. For example, opinions varied among the interviewees about the ability of performance measurement to drive productivity and create improvements in the industry. Even if many of the interviewees considered measurements to be valuable for both present and future projects, this view was not shared by everyone. Some of the interviewees were

questioning the purpose of documenting the results from the measurements, whereas others did not understand how performance measurement could be beneficial since every project is unique and so will be the execution and challenges related to it. As one of the interviewees argued: "Why should you spend time measuring something that has already been done? If something has gone wrong for a discipline, how could you use that information when the activity does not repeat itself later in the project." (Interviewee #9). Another interviewee noticed: "It is just numbers that float around and does not make any sense." (Interviewee #12).

Several of the interviewees implied that performance measurement would not "be valuable" for them and argued that "It doesn't really matter to me, we are just following the weekly work plan, and if we can do so, then everyone is happy." (Interviewee #11). Some simply felt they would not have the benefit of learning something new, admitting that they felt "a bit old to understand all of these new systems. It should be handed over to the youth to handle." (Interviewee #5). Indeed, several of the interviewees found performance measurement, and the metrics within the LPS, quite comprehensive and complex, and therefore questioned its value. Some of them concluded that it would not be useful for them to implement because of the "hassle" of doing it, and that it was difficult to prioritize the time. However, one of the interviewees admitted that he had been one of those who used to question the purpose and necessity at the beginning but after using it for some time, he began to realize its value. "In the beginning, I thought it was burdensome and I did not quite understand why I should prioritize measuring PPC. However, the more I used it, the more I understood and saw the value of it. And in the end, I realized that I do not really have time to not measure PPC on the project." (Interviewee #6).

Many of the interviewees acknowledged that they had to put up a good case for justifying the extra time spent, but as illustrated by the quote above, some of them had realized that they did not have the time to "not do" the measurements as it provided the opportunity to gain time. Nevertheless, the findings indicate that even if some of the project managers and central level managers indeed saw the value of measurement, there seemed to be a general lack of motivation for measuring performance among the interviewees, and that it was considered time-consuming with few benefits, both among managers and workers.

Related to the above was an apparent lack of knowledge of and a coherent system for how to measure in the company, according to the interviewees. For example, interviewees who had no previous experience with performance measurement explained that the lack of a common method created insecurities and confusion. Consistency and a well-implemented system were mentioned as two of the most important aspects to sustain good measurement and indicators. Consistency in the way that performance is measured was considered central, or else "the indicators will lose their value," as Interviewee #1 explained. A key argument was that a well-implemented and structured system enables the users to get a better overview of the lookahead plan and to map the different conditions for a healthy activity. It was emphasized by several of the interviewees that even if project participants have a good technical understanding and access to different systems and programs, many of them do not understand how to perform performance measurements and neither spend time nor energy figuring how they should do it.

It was widely held among the interviewees that it is important to be aware of the human conditions in relation to performance measurement. Another key challenge related to performance measurement was therefore associated with how individuals perceive the process and results of measurements. Many argued that caution should be exercised in how the numbers were communicated and used. A number of the interviewees were particularly concerned that if the measurements are used with the wrong intentions, the effects will have negative consequences such as poor motivation.

One of the interviewees argued that it is important that the numbers are used as indicators and not for explicitly defining if someone is doing a good job or not. This statement was supported by one of the project managers, who argued that when measuring an individual's performance, one measures how fast they work. In doing so, the workers can get the impression that they are not working "fast enough." Many contended that the purpose of measuring is misconceived if the measurements are conducted only for the reason of collecting numbers. As another of the project managers explained: "The rationale behind measurements is not related to the ability to expose someone, or attempts to compare, based on one's ability to "run fast". On the contrary, the intention is to identify areas for improvement." (Interviewee #6). To avoid being misunderstood, the manager felt forced to keep the numbers hidden, since "some numbers could be harmful." As a result, instead of presenting the numbers as statistics by emphasizing a quantitative approach, he chose to make it a qualitative process, focusing on potential improvements and strategic prioritization of time.

Related to the identified challenges mentioned, the importance of having a common understanding of the purpose behind the measurements was highlighted by several of the interviewees, and many saw this in relation to the cultural aspect. One of the interviewees, who had experience from the international construction industry, explained that in other parts of the world numbers and statistics on performance are commonly communicated in the open, "while in Norway, it is not so culturally accepted." (Interviewee #1). Thus, even if some considered performance measurement as an important means to achieve greater productivity, they emphasized the degree of trust, involvement, commitment, and a common understanding as critical when performing this type of measurements. For example, to accept being measured, some of the interviewees noticed that they then had to be involved and be able to make a real impact on the plans. One of the interviewees concluded that if performance measurement negatively affects the working environment, it is not "worthwhile." These reflections were shared by the interviewees from the other construction company that we interviewed.

Discussion

In the LC literature, performance measurement is considered an implicit part of LC concept and the LPS (Ballard & Tommelein, 2016). Like the general literature on performance measurement (e.g., Kaplan & Norton, 2004; Neely et al, 2002), the LC literature emphasizes that the key principles of LC (including measurements) must be accompanied by a consistent implementation strategy, which involves every actor participating in it (Mossman, 2009; Sage et al., 2012), and the associated training (Porwal et al. 2010). However, in our study of ConstructCo, we generally found low adoption of key LC and LPS metrics across the projects in the company. While the company had gone

through a relatively structured process of implementing LC, which involved developing the CP and associated guidelines, as well as training, the measurement element was not that focused in this process. For example, even if CP included a focus on the seven conditions (Koskela, 2000), and PPC was explicitly mentioned in one of the two CP guidelines, there were no formal tools or guidelines for how to conduct measurements in relation to CP.

A few of the projects had implemented PPC but many of the interviewees noticed that they lacked tools and knowledge about how to do the measuring. Furthermore, other LPS metrics, such as TA and TMR (Ballard and Tommelein, 2016) were neither mentioned at all by the interviewees nor commonly recognized although the reasons for deviation were largely related to the poor performance of TA and TMR. Thus, while the LC literature suggests that several metrics should complement each other to provide benefits of LC and the LPS (Ballard and Tommelein, 2016; Barth et al. 2019; Hamzeh et al. 2019), this was clearly not the case in ConstructCo. In addition, some of the interviewees noted that they probably measured more than they declared and that these measures resembled the LPS metrics without referring to them as such.

One key finding of the study is that when a more formal and systematic approach lacks the adoption of performance measurement then it is largely dependent on individual preferences. In the projects where measurements were used, it appeared to be based on individual preferences and experiences. This aligns with previous literature, which argues that managers in the construction industry largely make decisions based on experiences and intuition (Lantelme & Formoso, 1999). A good example is the project manager who noticed that after rather reluctantly starting its use, not using it was not an option. This finding also confirms the argument by Kalsaas (2013) that experiential learning is an important driver in adopting performance measurement, and that LC measurement often requires much learning. The finding also indicates that when measurement is seen to contribute to continuous improvements and learning (Hamzeh et al., 2009), it increases the motivation to adopt it.

Another key finding of the study is that different attitudes and opinions towards performance measurement hinder a broader adoption. In ConstructCo, there were several people that acknowledged the value of performance measurements but there were also many counterarguments and concerns regarding the value gained. For example, there was skepticism to why one should measure what has already happened and the fact that the same activity would not be repeated later in the project. There was also skepticism about how the measurements were conducted and how the results were used. How individuals perceive the process and results of measurements is a central issue in the general literature on performance measurement (e.g., Neely in Powell, 2004). Like what has been emphasized in the general management literature (e.g., Smith & Bititchi, 2019), many of the interviewees were concerned that if the measurements are used with the wrong intentions, the effect will have negative consequences such as poor motivation and work environment. This finding reflects the argument in previous LC research about the importance of acknowledging the social and political aspects of LC (e.g., Bygballe et al. 2018; Green & May, 2005; Sage et al. 2012).

The study also provides the basis for deriving some key insight on what it takes to overcome the above challenges. Performance measurements could be beneficial as a basis for making improvements, but it needs to be conducted in a systematic way, where individuals are involved and have a common understanding of how it should be used and

“why.” The study demonstrates that the extent to which the different trades were involved in CP and setting the goals varied. For example, some of the interviewees argued that because they had not been involved, they would not take responsibility if their performance was not complying with the productivity goals set by the management team. This illustrates Nealy’s argument (Powell, 2004) about the risk that poor measurements are used in an intimidating and judgmental way by management and will trigger defensive behavior.

To implement performance measurement, it is therefore important to have a common understanding of how and why. Involving people more intensely is likely to increase their motivation for productivity improvements because it allows them to take responsibility and control of their activities (Koskela, 1992). The differences between interviewees at different levels - where project managers responsible for measuring and using it seemed more positive than those being subjects to measurement - illustrate this. Trust is critical in this respect since it is a self-reinforcing mechanism. If there is trust in the sense that positive (rather than negative) expectations about performance measurement are met, both in the way it is used and the results it provides, the motivation for adopting performance measurement in relation to LC and the LPS is likely to increase.

Conclusion and implications

We started this article by asking: How and why is performance measured within the LPS? What are the resulting challenges, and how might these be overcome? By answering these questions, our study contributes to expand LC literature on measurements (e.g., Ballard & Tommelein, 2016) by demonstrating how performance measurement is related to the LPS in a practical case (i.e., in ConstructCo), and the challenges that a company faces in implementing such measurements. It therefore also adds to the LC implementation literature (e.g., Sage et al. 2012). While it confirms findings in previous studies that there is a need for paying attention to both formal and informal conditions in implementing LC concepts (Bygballe et al., 2018), the study addresses this interplay more specifically in relation to performance measurement and the LPS. It demonstrates that there is need for both formal procedures and tools to provide the projects with a consistent system to measure performance from which they can reap what are identified as valuable inputs to improving work, time management and learning. However, at the same time, caution is warranted because people have different views on the need for and/or value of such measurement.

For practice, our study highlights that performance measurement should be an inherent part of LC and the LPS but that it requires a systematic and strategic approach. This cannot be forced upon the projects and individuals but should be developed by involvement and through a debate to create commitment. There is a risk of misuse of the metrics and the results. Thus, it is important to know and be aware of what lies behind the measurement and the numbers to be able to use them in an appropriate way. If not, it can easily create myths and a distorted view of the measurements. One of the interviewees in the study, a professor of motivation theory, explained that in a “performance climate” one is encouraged to collaborate and mutually exchange ideas and thoughts. The emphasis is placed on learning and developing, where workers are encouraged to try new methods and

solutions in their work processes. However, in a climate where “the result” is the focus, performance is measured based on a comparison between colleagues’ performance. This type of internal competition encourages achieving the best possible result, and only those who perform best are acknowledged. The professor further stated that research had shown that there is a positive correlation between this type of climate and burnout and high turnover. While “Performance climate” is positively related to work engagement, commitment and motivation and negatively related to burnout and high turnover. These are important insights for our purposes on how challenges of performance measurement in relation to LC and the LPS can be overcome. We believe they illustrate very well the findings from the study and the interviewees’ arguments about what type of culture should be pursued when implementing performance measurement in relation to LC and the LPS.

Our study has some obvious limitations that should be acknowledged. We have given a “real” but single account of how performance measurement is considered in a construction firm, which uses LC principles, and identified key challenges of these efforts. This has allowed an in-depth exploring of the phenomenon, revealing interesting issues but it does not allow for any generalization. Thus, even if our study cannot be generalized statistically, we believe our findings are relevant for other, similar construction companies implementing performance measurement in relation to LC and the LPS. However, we also recognize the specific characteristics of ConstructCo. The company has for several years focused on worker involvement. We also note that Norway might be a special case due to its specific work conditions emphasizing work empowerment (Lohne et al., 2021). These characteristics are likely to influence the way performance measurements are used and perceived. Despite these limitations, we have sought to ensure the quality of the study, such as interviewing not only ConstructCo employees but also representatives from another company and three expert professors in the field. Furthermore, we have related the findings to relevant literature, which allows for analytical generalizability (Yin, 2017). Research on LC and performance measurement in general urges for sensitivity being paid to the social aspects of implementation. We therefore believe that our study might form the basis for future studies of how and why performance measurement is used in combination with LC and the LPS, and further examination of the effects that it might make, and the formal and informal conditions thereof.

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