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FINDINGS ON THE USE OF THE LAST PLANNER SYSTEM—A CASE STUDY

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ABSTRACT

The last planner system™ (LPS) is a production control method used in lean construction projects that has offered good results to construction companies in terms of improving labour productivity, increasing collaboration and the possibility for developing continuous learning. This short study contributes to LPS research on the reliability of promises and how parties perceive their effects on schedule and productivity. The study was conducted using a case study on an industrial construction project in which LPS had been in use since its start. Research data were collected using a semi-structured survey conducted online due to the pandemic. The study also utilized project progress data and measurement data from the LPS sessions. The most interesting result of the study was how little the LPS participants felt they had to compromise their goals. We also found how scheduling methods used in parallel with LPS can frustrate users and contribute to reducing its usefulness. Our findings can be used in further research in several ways, either by utilising the questionnaire we developed or by comparing our findings to other studies. We believe that practitioners using LPS will benefit from our results and can use them to address these shortcomings identified in future projects.

KEYWORDS

Lean construction, last planner, reliable promises.

INTRODUCTION

Project activities have become more complex over time, and this complexity is reflected in the complexity of construction-related tasks, the growing interdependencies between tasks, cultural complexity, and social complexity (Girmscheid and Brockmann, 2008; Luo et al., 2017). There are also more and more employees from different cultures in construction projects, and the number of participants in the projects has also increased and spread geographically compared to previous decades (Ochieng et al., 2013). Partly because of this, terms such as collaboration, decentralization, commitment and trust are increasingly used in construction research and applications (Alves and Tsao, 2007).

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Solutions based on these factors have been sought in this complex world of construction, and one of them is the LPS method developed with lean construction. The LPS is a collaborative and commitment-based planning system with should-can-will-did planning at its core (Elfving, 2021). First, 'should' refers to the phase in which sections of the master schedule that define what should be done are scheduled. Next, lookahead planning is based on what 'can' be done once the constraints on work have been removed, while weekly work is planned in the LPS through reliable promises to agree on what 'will' be done (Ballard et al., 2002). Finally, 'did' in the LPS is continuous learning based on identifying and eliminating the root causes of failed task planning on a permanent basis (Liu & Ballard, 2009).

At the heart of the LPS, transparency between parties is essential, as it enables reliable promises to other parties and the building of trust (Howell et al., 2004; Fauchier & Alves, 2013). However, trust does not arise in an instant and is a complex phenomenon (Lühr et al., 2021). Moreover, the reliability of promises regarding the use of LPS has been extensively studied. For example, Tommelein et al. (1999) emphasized the key role of owners, architects, engineers, and construction managers in enabling reliable promises and preventing unreliable workflows. Priven and Sacks (2015) examined 12 residential construction projects through an action study and found that the use of the LPS strengthened the social networks of professional trade crews. In their study of 26 projects, Fernandez-Solis et al. (2013) found that the use of LPS significantly improved workflow and communication between the involved parties. However, focusing on a reliable workflow and promises also puts pressure on individuals to make and keep these promises, which can also reveal conflicting organizational practices (Koskela et al., 2007).

One important motivator for the growing popularity of the use of LPS in construction is the pursuit of better productivity, which has also been extensively studied. For example, Ballard and Howell (1998) found that the use of LPS significantly improved productivity in several projects. Further, González et al. (2007) showed that a high number of reliable promises led to higher labour productivity, while Liu et al. (2011) identified a similar relationship between productivity gains and workflow reliability in pipeline installation crews using the LPS method. However, several factors may limit the positive development of productivity despite the use of LPS. One common constraint is high employee turnover (Shang et al., 2012). High employee turnover can have a detrimental effect on both reliable promises and continuous learning, which are the two main components of LPS. Another important factor in the productivity of construction work is employee satisfaction (Sageer et al., 2012). Interestingly, for some employees, the use of LPS is evidently painless, and labour productivity has improved, but for some, the use of LPS itself has had the effect of even resigning from their work (Kalsaas, 2012). Therefore, the use of LPS is not one-dimensional and free from fears, restrictions, and boundary conditions in the construction industry.

The use of the LPS requires the involved parties to be willing to negotiate and even compromise on their own goals for the benefit of others and the whole (Ballard & Tommelein, 2021). However, the emergence of such willingness in a project is often challenging, as Jørgensen et al. (2004) observed in their study: construction professionals may not understand the concept of lean construction and slip back into old roles; project members do not generate a willingness to share information, they do not compromise on their own goals, and they consider suboptimization instead of the overall performance of the project. Negotiations between the parties in front of the LPS tables require the ability of individuals to enter into social agreements. Priven and Sacks (2016) proposed social

subcontracting as a solution to the problem. Their idea is to improve communication, mutual respect, and co-operation between the parties between the main contractor and the representatives of the subcontractors (Priven and Sacks, 2016). Using the process and artefacts developed for this, a written agreement is created to express an understanding of how the site will behave, how the relationship can be strengthened, and how this agreement will be monitored (Priven and Sacks, 2016).

The role of the project manager while using LPS requires certain mental model changes. In the LPS method, the project manager must transform from a traditional command and control management model towards a coaching management approach (Bach, 2014). To succeed during the LPS sessions, the leader should be able to create optimism, hope, resilience, and, above all, openness and trust among the participants (Fauchier and Alves, 2013; Bach, 2014). For example, if a leader is unable to transform and does not act openly and shows distrust in LPS sessions, it will inevitably affect the success of LPS (Priven and Sacks, 2016).

LPS also challenges the old roles of developing schedules and shifts the focus of schedule planning from that of a solitary planner to a collaborative huddle (Hamzeh, 2011). However, in reducing the level of scheduling to the required last-planners level, gaps in the flow of information to higher-level schedules (such as master and phase plans) have been identified. Furthermore, project managers or other schedulers have to spend a lot of time compiling the LPS data and dividing it into other schedules (Dave et al., 2015).

The use of LPS has achieved positive results in the construction industry in several countries (Daniel et al., 2015). However, there are also gaps related to the precision of LPS and the reliability of promises that have not been adequately addressed in previous studies. Accordingly, this article aims to fill the gaps related to the precision of LPS and the reliability of promises that have not been adequately addressed in previous studies. Nevertheless, we are aware that previous research has highlighted the connection between reliable promises and improvements in productivity (Ballard, 2000; Liu & Ballard, 2008). However, only a small number have used large industrial construction projects as their research objects; thus, our research is an additional contribution.

METHODS

The semi-structured online survey method was chosen for one Finnish industrial construction site where LPS has been in use for a year. A semi-structured survey, combined with the opportunity to provide free feedback, was found to be suitable for this short survey, as such a method is time efficient for both interviewees and interviewers and is not overly resource intensive (Allen, 2017). On the other hand, the disadvantage is that some potential participants inherently exclude these types of methods, and in that respect, the sources of information remain less rich than in direct interviews between individuals (Johnson & Braun, 2016).

The research proceeded in phases. In the first phase of the study, the author, who acted as facilitator, observed LPS sessions and documented them with photographs and his own free-form notes. Sessions were held weekly, and at the busiest stage, the sessions were divided into two different days. During the first phase, PPC measurement data were also collected in Excel spreadsheets. The final phase was to conduct an online survey and analyse the results of the survey.

Moreover, one of the authors of this study also acted as a facilitator of the LPS sessions and observed the behaviour and actions of the involved parties. The PPC values measured in the LPS sessions were also available for the authors and were used as

complementary data in this study. There were also features of action research in the observation, as the facilitator himself participated in conducting the LPS sessions. However, this was not done in a methodologically systematic and structured way, so it involved participant-observer bias (Given, 2008). His observations were used in this study primarily to evaluate the results of questionnaires and examine the meanings of open-ended responses. This paper reports the findings related to observations, and future work will continue to develop an improved plan and action through the findings and reflection reported in this paper (Baskerville, 1997).

The choice of research subject was influenced by the fact that two of the authors were working on the project under study, making it possible to acquire available data for research use. The construction work on the aforementioned project was led by a construction management consultant, whose staff was integrated into the client's organization, which had the responsibilities of the main contractor. The subcontractors were responsible for their own sub-areas, and the contractual relations had been concluded directly with the customer. The contracts included an obligation to attend the LPS sessions, and at the beginning of work, short training sessions were held by the consultant for those with no previous experience using the LPS. The project's total gross area was about 200,000 m^2.

At the time of the study, LPS sessions had been used in the project for 10 months. Specifically, the LPS consisted of two parts: 1) master and phase planning and 2) make-ready and weekly planning as well as learning. However, master planning had already been done before construction began, while phase planning was largely tied to a traditional phase schedule without collaboration with contractors. In the model used by the CM consultant, the LPS was used for part 2, and each contractor began the weekly LPS sessions upon arrival at the site. Specifically, make-ready and weekly planning were done on physical boards using sticky notes, while learning took place through root-cause analyses, which were held separately. The principle of root cause analysis was that each individual deviation was not examined, but recurrent ones were examined in more detail to eliminate the root cause. All root causes were classified and discussed in front of the LPS boards, but the analysis was done separately in a smaller group after the session.

In addition to the LPS, the contractors used the traditional S-curve (i.e., the progress curve) and three-week schedules, which essentially had the same content as the LPS tables. However, in the LPS sessions, the emphasis was on presenting tasks that had an impact on the work of others. This means that in situations where the contractor had a lot of work in his area but no other contractor had worked there yet, it was agreed that the number of tasks would be limited to those with an impact on the vicinity of the contract area or those requiring coordination. The typical duration of the session was 30 minutes, but it could be within the range of 15–60 minutes, depending on the difficulty of the tasks to be planned.

A total of 93 participants in the LPS sessions were selected to participate in the survey. The survey was sent to the participants via e-mail. Additionally, in two of the LPS sessions, a QR code was distributed on a sheet of paper, allowing the participants to answer the questions on their mobile devices. To focus the survey questions on the research problem, the questions were divided into six parts as follows: 1) experience using the LPS, 2) level of detail of the schedule, 3) compromising goals, 4) staying on schedule, 5) reliability of promises, and 6) work productivity. The answer scale for the questions was compiled using a Likert scale. Space for free feedback was given at the end of the

survey and did not require answering. The interview questions and answer options are presented in Table 1.

Table 1. Questions and Likert scale of answers

Q1: How satisfied have you been with the level of detail of the schedule established by the LPS?					
Likert scale for Q1	1 Very dissatisfied	2	3 Neither dissatisfied nor satisfied	4	5 Very satisfied
Q2: How often do you have to compromise on your own goals in an LPS session?					
Likert scale for Q2	1 Never	2	3 Sometimes	4	5 Almost always
Q3: How often do other parties have to compromise on their own goals in an LPS session?					
Likert scale for Q3	1 Never	2	3 Sometimes	4	5 Almost always
Q4: Compared to your other projects, how well have you stayed on schedule for this project?					
Likert scale for Q4	1 Very badly	2	3 Neither good nor bad	4	5 Very well
Q5: Compared to other projects, how well have other parties stayed on schedule for this project?					
Likert scale for Q5	1 Very badly	2	3 Neither good nor bad	4	5 Very well
Q6: The other parties give you reliable promises in the LPS session.					
Likert scale for Q6	1 Completely disagree	2	3 Neither agree nor disagree	4	5 Completely agree
Q7: How did the use of LPS affect labour productivity?					
Likert scale for Q7	1 Very negative	2	3 Neither positively nor negatively	4	5 Very positive

It should be noted here that while it was mandatory to answer the structured questions Q1–Q7, the option ‘I can’t answer’ was also available.

RESULTS

Overall, there were three general observations regarding the LPS sessions. First, at the beginning of the project, participants were fairly involved in the sessions, participation was active and planning issues were jointly discussed. However, as the project progressed, the facilitator observed mild frustration with the LPS method among the participants. This seemed to have started at the same time as the mechanical installation work, for which separate coordination meetings were actively organised between the construction and mechanical teams. In these meetings, some of the same issues as those in the LPS sessions were discussed, and they resulted in an aerial view of the area, which made it easier for contractors to mark their own weekly work areas.

Second, the representatives of the company responsible for the main mechanical equipment installations at the plant were very sceptical about the dates indicated on the LPS boards. This was increasingly observed by the facilitator, especially as the end of the 10-month follow-up period approached (i.e., when the volume of the mechanical installations began to increase substantially). Furthermore, at the same time as the observation, the LPS level also eroded significantly. Figure 1 below illustrates the diminishing development of the planned percentage completed (PPC) in one of the main areas of the site.

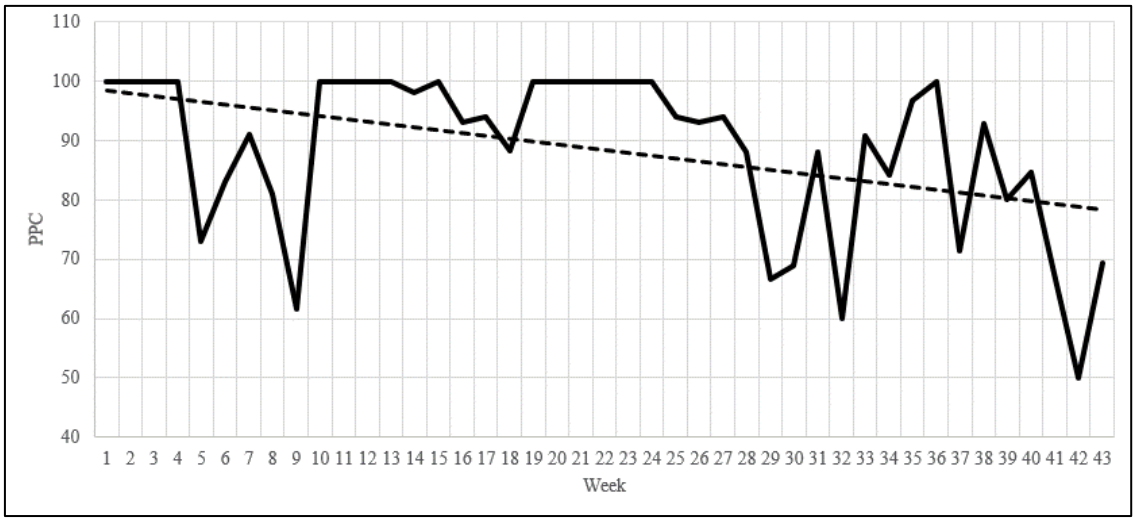

Figure 1. Decreasing PPC from one location as an example

The third observation relates to reliable promises. As the LPS sessions progressed, there was hesitation among the contractors regarding the tasks prepared by the others. Consequently, they began to postpone their own tasks to further away from those of the contractor performing the previous stage of work. In most cases, these findings were made using the information on the LPS boards, where it was clear that the contractors in the previous phase had not been able to keep their promises, and those in the next phase already had to postpone their own tasks due to a lack of reliability.

The interview survey was opened a total of 51 times, and responses were received from 19 individuals, which is a 16.1% response rate. The respondents were as follows: one foreman, three construction managers, three supervisors, seven responsible foremen, two site managers, two project managers and one site engineer. The majority of the respondents were well-experienced: 10 respondents had more than 20 years of work experience, three had 16 to 20 years, two had 11 to 15 years, two had six to 10 years, and only two had less than five years of experience. Of the respondents, one was an earthworks contractor, 10 were cast-in-situ concrete contractors, one was a prefabricated concrete contractor, and seven were other contractors. Moreover, 53% of respondents had previous experience with LPS, while 47% had none. Specifically, two respondents reported having used the LPS in previous project management contracts, two had used it at an industrial site and one at an infrastructure site. The results of the interviews are presented in Table 2.

Table 2. Survey results

Question	Min	Max	Average	Median	Std.dev.	Answers
Q1	2	5	3,3	3	0,7	19
Q2	1	4	2,2	2	0,8	18
Q3	1	4	2,5	3	0,8	15
Q4	2	5	3,6	4	0,7	18
Q5	2	4	2,9	3	0,8	15
Q6	1	4	2,9	3	0,9	17

Q7	2	4	3,2	3	0,8	15

Responses to the level of detail of the schedule were neutral. However, those to staying on one's own schedule were more positive (average 3.6) than 'perceptions of other parties doing the same (average 2.9). Respondents felt that, on average, they had to make a few compromises in their schedules (average 2.2), nor did they feel that other parties had to make substantial compromises (average 2.5). Nevertheless, they were neutral about reliable promises and the impact of the LPS on labour productivity. Comparing informants who had experience using LPS in previous projects with informants who had no previous experience using the method, interesting differences emerged. For example, for question 1, the group with no previous experience had a mean score of 0.6 points higher (3.0/3.6) and a median 1 point higher (3.0/4.0) than respondents with previous experience with the LPS method. Similarly, in question 5, the responses of these groups differed, and respondents with no previous experience using the method responded with a mean of 3.3 (more experienced group mean was 2.4) and a median of 3.0 (more experienced group median was 2.0). The groups also responded slightly differently to the reliable promises of the other parties (Q6); the group with no LPS experience answered the question with a mean of 3.2 (mean of the more experienced group was 2.6), with a median of 3.0 (median of the more experienced group was 2.5). In terms of labour productivity (Q7), the more experienced group also responded with lower means (3.0/3.4) and median (3.0/3.5) than respondents with no previous experience with LPS. In this response, more experienced responses also had a more variability than more inexperienced LPS users.

Free feedback was provided by nine respondents, and their open-ended responses are summarized in Table 3 below.

Table 3. Open-ended answers

Answer	**Positive**	**Neutral**	**Critical**
A lot of work has been done in other meetings and with other tools (memos, charts, to-do lists, sharing the traditional schedules). The LPS has been given a side role, although it could be the main tool. One reason is the impractical location of the LPS boards. Other coordination meetings could be held on the same board. The plan drawings added to the background of the boards are not quite enough to support the discussions. Maybe there should be a separate board on which the 'tightest' places could be added.			X
More post-it-notes should be included on the board.		X	
Underground pipeline design shortcomings / delays play a big role for every actor in the area in terms of cost and schedule.		X	
Six weeks is too long to evaluate as there will be so much change that such a forecast will not come true.			X
There were very few other contractors on the same board; for e.g., the benefit of the LPS has been negligible from the perspective of the contractor as it is being filled 'for oneself'.			X

From the point of view of the project manager, it is difficult to take a position on the survey. However, as an outsider, it appears that the LPS helps to better perceive the whole and ensures that no critical step is missed.	X		
That post-it-note 'doesn't work, it 'doesn't show the 'whole'. If a contractor does not stick to the agreed-upon schedule, then there is nothing useful in the LPS. No other schedules were seen in the sessions, and one could not properly compare the LPS to anything. I don't think it's a very good way to steer the project right now.			X
The LPS seems useless, and the S-curve is just OK.			X
There should be more post-it notes on the boards. Mechanical installations should also be included.		X	

As shown above, the open-ended responses were mainly criticism and neutral feedback. Specifically, the need to get more tasks on the LPS board was repeated in two of the answers. Similarly, two respondents stated that the LPS remains on the side lines due to the availability of other scheduling tools. The space reserved for boards, which is a construction site canteen, was also criticised in one response. Finally, two respondents specifically pointed to infrastructure work (piling and underground pipes) as a problem that was not adequately reflected on the LPS boards.

DISCUSSION

The most significant finding of this study was that the parties did little to compromise on their own goals and did not feel that others had to do so, either. This observation may indicate that they were able to negotiate a consensus during the LPS sessions that was acceptable to everyone and move forward in their work. The 'facilitator's observations, especially from the beginning of the project, also support this conclusion. This is in line with the findings of previous studies, such as Fauchier and Alves (2013) and Ballard and Tommelein (2021). In contrast, the results may also mean that the parties did not hold each other accountable and thus did not have to compromise on their own goals. However, this meant that they also did not have to resolve conflicts between the other 'party's goals and their own. Nevertheless, the observational findings suggest that during the session, the parties negotiated a compromise that everyone was able to work with in the following weeks and without having to significantly compromise on their own goals. Regardless, this can pave the way for more collaborative contract agreements that are beneficial for all parties (Chen et al., 2012). However, this requires further research and a more open-ended approach.

In terms of schedule, reliable promises and labour productivity, responses were neutral and similar to the observations of Power et al. (2021). When the open-ended answers were compared with those to the structured questions, the scheduling tools used in the project alongside the LPS seemed somewhat frustrating for the respondents and made the latter feel unnecessary as just extra work. It is also noteworthy that despite the long-term use of LPS among the civil contractors, its usage was adversely affected by the coordination meetings that began at the start of the mechanical installation, which partly overlapped with the LPS' agenda and therefore had a detrimental effect on 'its use. This may also be indicated by the 'facilitator's observations of a later stage of the LPS sessions, where overlapping methods were already in place and consensus-building or heated debate diminished, with the parties perhaps feeling that the session was no longer the'

primary forum to coordinate ’schedules. These findings raise the following question: how does the use of overlapping systems affect LPS users? Earlier studies have suggested that the use of overlapping systems can confuse, frustrate, and impair the use of lean methods and often cause the return to previously used and familiar methods (Sacks et al., 2009; Simonsen et al., 2019). On the other hand, previous research proposes that even the partial use of the LPS improves workflow on site and that using it in combination with other methods does not impair site performance in light of research data (Priven & Sacks, 2015). Using overlapping methods can also impair group focus and performance. As the number of methods increases, mental activities become increasingly difficult and situational awareness of the ‘big picture’ becomes blurred (Rudolph & Repenning, 2002). The simultaneous use of several methods can also create increasing time pressure as the project progresses, which is normally experienced in projects, but when the time pressure increases sufficiently, it can impair group performance (Hansen et al., 2020). Future studies on this topic are therefore recommended.

Meanwhile, the authors did not see any signs of improved labour productivity or site performance in the responses, and this topic requires more quantitative data from the contractors. To improve productivity on a construction site, the manufacturing process must strive for optimal conditions. This is done by not only ensuring the presence of workers but also focusing on hiring the most skilled crew possible to perform tasks and ensuring optimal working conditions (Lindhard & Wandahl, 2013). However, in this study, although the LPS planning was done on a weekly basis, the flow of workers, materials, machinery, and space was not regulated or addressed in the LPS sessions, which was reflected in the open-ended responses, where most respondents criticized the use of LPS and doubted its usefulness.

Another factor that may have influenced the responses and criticisms about the use of the LPS among the interviewees was the general use of this system as a stand-alone tool without a broader understanding of lean philosophy (Hamzeh, 2011). As Hamzeh (2011) and Sarhan and Fox (2012) noted, the introduction of the LPS is not just in terms of its implementation as a tool in a project. Instead, it is necessary to change people’s thinking, ways of working, i.e., culture and enthusiasm to depart from the status quo. Moreover, in the LPS sessions, leadership has to nurture and support so-called ‘soft values’ that have been found to improve schedule reliability and thereby participants’ productivity as motivation, responsibility, and ownership increase (Lindhard & Wandahl, 2013). The responses of the interviewees contribute to the findings, as we found that there was little need to compromise on one’s own goals, and that several different schedule-related meetings and scheduling tools competed alongside the LPS, so there was no genuine shift in practices or culture towards the lean way of thinking.

On the other hand, the effects of social and cognitive phenomena were not the aim of this study, but the emergence of social agreements between participants in LPS sessions, for example, deserves further research. The importance of social agreements has been widely recognized (Gigerenzer & Hug, 1992), and their effects in social situations such as LPS should be studied. In particular, the importance of keeping reliable promises in situations where social contracts are violated (e.g. by cheating others) is an interesting topic for future LPS research.

CONCLUSIONS

Despite the small sample size of our research, we believe that our findings support those of previous studies on the challenges of using the LPS in project environments that focus

on using individual tools rather than generating a lean culture. Additionally, our research also raised specific questions about how little the parties considered compromising their own goals in the LPS sessions. In this context, we suggest that further research related to the topic of compromising goals be carried out on projects where the LPS is used.

Moreover, our research findings cannot be generalized because the data was collected from only one Finnish industrial construction project. In addition, the small number of respondents relative to the number of participants in the LPS sessions may have affected the reliability of our study. Regarding the validity of the study, since the manner in which interviews were conducted and the kind of questions asked of participants are made clear, it is straightforward to repeat this study format in a different project. Further research on this topic would be of great help in understanding the challenges faced by LPS users.

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