

SUBCONTRACTOR COLLABORATION AND BREAKDOWNS IN PRODUCTION: THE EFFECTS OF VARIED LPS IMPLEMENTATION

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ABSTRACT

The benefits of Last Planner System® (LPS) implementation on a whole project are well established in literature and research about Lean Construction. Throughout the construction industry LPS has been adapted to meet owner needs; industry requirements and individualized to Construction Management specialties. However, the impacts of varying LPS structures, interpretations or deviations implemented by the Owner/ General Contractor/Construction Manager have shown diverse effects on the upstream and downstream flow of construction operations and production specifically relating to subcontractors trades. This variation has led to decreased schedule reliability and ineffective constraint analysis. There are behavioral aspects and sub trade levels of engagement to consider during the implementation of LPS. The authors through surveys, interviews, and direct observations analyzed the specialty trades perceptions of Owner/ General Contractor/ Construction Manager adapted implementation of LPS. Research analysis identifies how variations in LPS implementation lead to failures and losses in productivity, which reduce buy-in of the subcontractor trades. Potential tools, processes and behaviors to mitigate these variations are suggested and analyzed.

KEYWORDS

Last Planner System, Pull, Lean Construction, Work Flow, Collaboration, Promise, Trust.

INTRODUCTION

For the past decade LPS has become increasingly prevalent in the construction arena. With a need to understand the effects of dependence and variation along supply chains and the relationships of teamwork, communication and contract the LCI has promoted the focus (Howell, 1999). Different methods and interpretations have increased alongside industry interest in implementing LPS. As varied approaches to the LPS increase so has a lack of trust of the system. The same reaction was documented through research by Koskenvesa and Koskela, “People went from a feeling of comfortable stability into a feeling of panic. People seem to be happy staying in a comfort zone where people generally don’t need to learn new things and therefore don’t change” (Koskenvesa & Koskela, 2012).

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In other countries major companies have become aware that trust, reliability and stability in production have become an issue that LPS can resolve. (Koskenvesa & Koskela, 2012) Research performed by Glenn Ballard suggests that “The problem is that production systems just do not work well when every person tries to optimize their performance without understanding how their actions affect the larger web.” (Howell, 1999). Full implementation of the Last Planner System allows for an encompassed, centralized project management structure adaptable to any given project and geographical location.

THE HUMAN CONTEXT OF LAST PLANNER SYSTEM

The Last Planner System (LPS) is a defined production planning process that allows for the synchronization of multiple workflows, identification of deficiencies while eliminating the waste or variations and allowing for continuous production (Howell & Macomber, 2002). To create a continuous flow LPS promotes collaboration, team work, trust and reliability. Merriam-Webster defines trust as the assured reliance on the character, ability, strength, or truth of someone or something. Reliability is defined as the quality or state of being reliable; giving the same result on successive trials. Trust and reliability are applicable forms of human context and not applicable to the science of physics. However, in LPS human context is being used to implement and increase the physics of production (Pavez & Gonzalez, 2012). Enabling the collaborative construction environment allows for people to act collectively, coordinating multiple activities along with concerns and problems that arise (Pavez & Gonzalez, 2012). LPS promotes collaborative actions and goal alignment through the processes of defining customer promises; building a project team; milestone planning; pull planning sessions; look ahead scheduling; weekly work plans; tracking Percentage of Promises Completed (PPC) and root cause analysis (Figure 1). These individual processes of LPS are interdependent, also relying on an interconnected team. (Silvon, Howell, Koskela, & Rooke, 2010) When one task or sub process is overlooked and or varied in production, the buy-in, reliability and trust of the team members are compromised along with LPS and the overall production schedule. Due to the powerful nature of the human aspect of LPS one must address and attack project dynamics that negatively affect it.

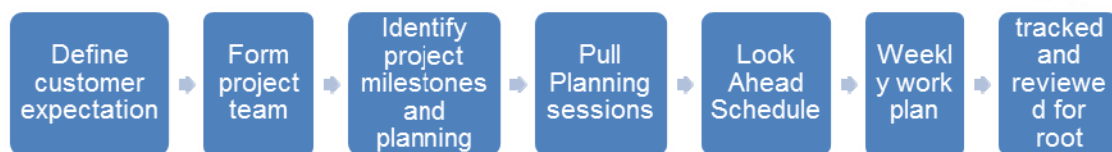


Figure 1: The Workflow of LPS

INTERDEPENDENCE & TEAM DYNAMICS

Construction projects are managed by highly interdependent tasks, sequences and roles amongst uncertain production environments, where poor coordination and lack of resources are common (Pavez & Gonzalez, 2012). The interdependent tasks, sequences and roles involved with the production process can be modified and managed by LPS. Through the interdependence of subcontract trades multiple

concerns or tasks, along with dependable promises made allows coordination between the team members based on trust. By aligning promises through pull planning sessions, tracking progress through look ahead scheduling and weekly work plans this allows transparency of all commitments, along with accountability of achieving the coordinated goals.

In LPS, trust is built when the fulfillment of the promise or commitment is completed in the coordinated time frame bi-directionally instead from the top down. (Howell & Macomber, 2002) Allowing for specific, challenging and achievable promises to be defined by the project team based on production needs, resources and workflow is an important factor in LPS. Promises are sequenced according to the subcontractor workflows in order to maintain a continual flow. When one promise is not met than downstream interdependent tasks are affected. Managing promises through weekly work plans and PPC (percent promises completed) allows a project team to remove the uncertainty from the workflow and align promises to achieve uninterrupted flow in production. The process of building the weekly work plan along with monitoring and reviewing PPC allows for increased team commitment and improvements in productivity. (Pavez & Gonzalez, 2012). As PPC is tracked, it is important for the project team to use the results to understand the root causes for non-completion of promises. Review of weekly promises where questions such as, are they attainable, achievable and well established, will allow for project teams to analyze coordinated tasks to ensure achievable results. Along with using Lean tools the project team can quickly discern whether the cause of a non-completed item is an internal or external factor. Understanding the root cause of a problem or variation, enhances the project team's collaborated efforts to improve upon the current state. The transparency of Lean and LPS allows team members to be proactive instead of reactive when identifying conflicts and concerns among multiple interdependent workflows.

HYPOTHESIS TESTING

Through observation of the current state of diverse construction projects it was our Hypothesis that the implementation of LPS by Construction Managers and Owners has a varied impact on the performance of the project and benefits to the subcontractor trades. The question researched was, what is the variation of Last Planner Implementation and how are the variations effecting the workflow of the subcontractor trades, along with their outlook of the effectiveness of LPS as a tool?

This paper combines field observations of (3) construction projects implementing LPS, a 10 question survey regarding LPS experiences, amongst a varied audience of construction industry professionals and interviews that were conducted by the authors to compare the effects of varied Last Planner Implementation. The interviewees were survey participants and associates of the (3) construction projects observed. The survey was delivered to 250 participants where 153 participated, 40 % of participants are subcontract trades, 40% are General Contractor and Construction Manager, while 20% were a combination of Owner, Vendor, Design team and consultants. The research focus was placed on how the subcontractor trades, along with team dynamics were affected by variation in processes. An interview with a Lean Construction expert who has been working in construction for 40 years with

Lean construction coaching and consulting experience over the past 9 years, was interviewed in regards to their experiences with the implementation of LPS.

Evidence provided to test this hypothesis is based on project observations by the authors, along with survey information and personal and expert opinions interviewed. Through the research captured we were able to define a small area of non-implemented areas and the downstream and upstream effects on the workflows of subcontractor trades. Further research should be done as far as root cause analysis from the Construction Manager, Owner point of view of why there is varied implementation and how this could be corrected. Through interviews and survey analysis, the most common factor for this reaction is the lack of trust and accountability of the management teams. The proper implementation of LPS harbors trust and accountability amongst the project team of Owner, Construction Manager and subcontractor trades.

RESEARCH ANALYSIS

LPS IMPLEMENTATION OVERVIEW

Implemented correctly LPS is a comprehensive production planning tool that allows for the increase of workflow reliability, the creation of sustainable work plans and the strengthening of project team dynamics. (Formoso & Moura, 2009) The (11) elements of LPS are shown below in Table 1: Evaluation of LPS implementation. As you can see the data collected shows which elements were implemented on the (3) projects observed for research data in regards to this paper.

As you can see from Table 1 all (11) elements of LPS had varied implementations on the projects. The variations that are observed on Projects 1, 2 and 3 in the implementation of LPS, created varied obstructions such as lag in workflow, unreliable production systems and a lack of trust among the subcontractor trades. When PPC was not tracked and management was not held accountable for commitments, collaboration on the observed projects was not attainable. Without collaboration or buy-in from subcontractor's improvements through LPS was not attained. Expert opinion states that if "LPS is not implemented in full you may as well not do it at all. As an LPS coach and user we would rather have people not use LPS than partially implement, because partial implementation leads to failure which damages the brand. (Fauchier, 2013)"

Neutral facilitation is valuable, but projects that implemented LPS only through a facilitator found that without buy-in of the Superintendents and Project Managers LPS will not succeed, as LPS is highly reliant upon all team members keeping commitments. You cannot give or exchange real commitment to a neutral facilitator who is only sparingly active on the job.

The projects that held closely to LPS realized increased collaboration for the entire team creating buy-in and trust. These projects through the increased participation and collaboration by subcontractors identified upcoming bottlenecks, variations and solutions in the field. It is noted in research by Pavez & Gonzalez that the planning reliability increases with the dynamics of the weekly work plan interface, and implementation of all (11) elements. This allows for increased reliability and team behavior to shift from advocacy for their own commitments to advocacy of project productivity and performance. When the team paradigm shifts from being

commitment based to productivity based, increased performance and d collaboration Occurs.

Analysis consisted of the observation of three projects that the implementation of LPS either from the beginning or throughout the project was administered. Please refer to Table 2 for project analysis. Along with observations research analysis was also obtained through interviews of spokesmen from local subcontractor trades. The analysis uses three main categories to group the findings namely: coordination and planning, accountability, and improvement.

Table 1: Evaluation of LPS Implementation on Observed Projects 1, 2 & 3

LPS Element	Project #1	Project #2	Project #3
1. Weekly work plan	Yes	No	Yes
2. Weekly meeting on time?	Yes	No	Yes
3. Attendance of key team members	Yes	No	Yes
4. Review of previous promises for completion	No	No	Yes
5. Analysis of non-completion for root cause	No	No	No
6. Commitment to new promises	Yes	No	Yes
7. Look ahead planning	Yes	Yes	Yes
8. Identification of constraints	Yes	No	Yes
9. Coordination of constraints	Yes	No	Yes
10. Improvement management	No	No	Yes
11. Publication of PPC/ root cause analysis	Yes	No	No
12. Contract IFOA	No	No	No
13. Interviews Performed	Yes	Yes	Yes

COORDINATION AND PLANNING

Three of the eleven implementation components of LPS are vital to the success of coordinated planning as follows. The attendance of key team members is one of the three components of LPS that are vital to a successful implementation. When conducting a pull planning meeting it is imperative to have the correct people involved from the beginning of the process. Project managers appreciate the collaborative nature of pull planning but eventually regress to collaborative planning with just one subcontractor due to relationships. Without the understanding that collaboration, negotiation and compromise must occur with all trades, the effectiveness and dedication by project team to LPS is minimal. A common question for the management team to ask is, who is performing tasks prior to the milestone we are pulling from? Much like a Kaizen event, a pull planning meeting should involve any stakeholders, the decision makers, and subcontractor trades impacted or part of the production of the workflows being defined. Strong executive buy-in and clear understanding and buy-in from the field Superintendents are a vital need to a successful implementation of LPS. (Fauchier, 2013) By incorporating the correct people in the planning and coordination of phase planning, all bottlenecks are identified bi-directionally and decisions can be made on the spot to clear all obstacles.

On projects observed, Project #1 included are vital tradesmen, impacting or being impacted by the coordination of the Pull Planning session. This lead to a well-coordinated schedule with minor bottlenecks. Project #2, did not involve all trade Foremen in the Pull Planning session, but rather project managers and Superintendents. The Foremen had given their input to the creation of the “stickies” and constraints but were not available for the actual coordination of the schedule. In the end of the pull planning session, many issues were identified; but the proper Foremen along were not there to coordinate through these issues give their input and buy-in to the coordinated schedule. The Foremen are the Last Planners. The foremen have the responsibility of final collections of resources and assuring that crews can work continuously. (Howell, 1999)Not having them in the meeting deprived the team of their direct project knowledge and the opportunity to collect commitments of the Last Planners to put work in place.

In interview of a subcontractor related with Project #2 , the subcontractor elaborated that the reason they did not always have Foremen involved in the Pull Planning meetings was due to budgeted labor for a plan and spec project. Labor hours are tight and even though the bid documents referenced possible pull planning sessions, there were not enough hours budgeted for these meetings along with lengthy Foremen meetings, look ahead meetings and PPC tracking meetings. So to minimize costs the Foremen were kept in the field while office personnel attended the pull planning sessions. Subcontractors with no experience in Lean often do not understand that if 1% of their budget was allocated to LPS and Lean initiatives the benefits reaped would significantly offset their investments. (Fauchier, 2013)

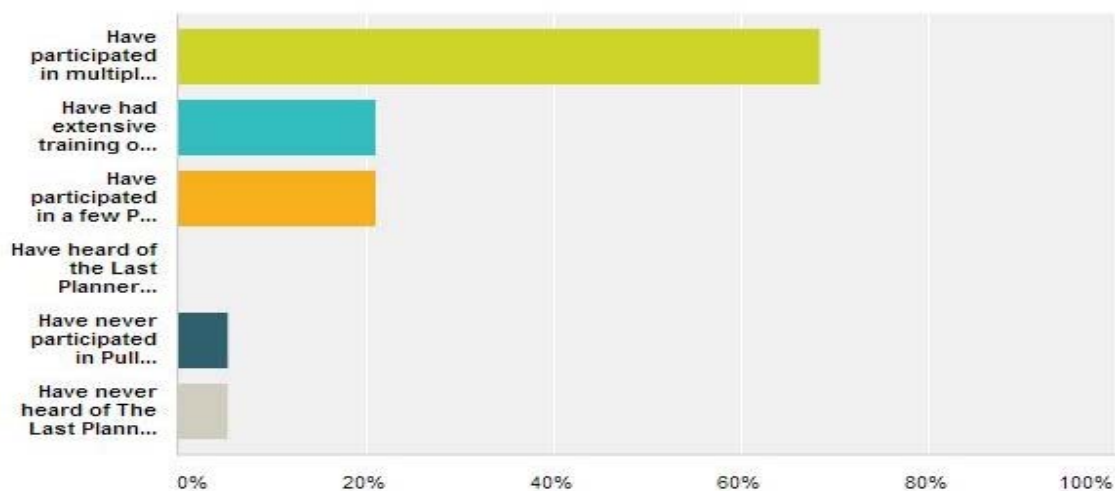


Figure 2: Survey Results for question “What is your experience with the Last Planner System and/or Pull Planning

The second of the three important elements of LPS is the weekly work plan and look ahead schedules. Survey results showed that 61%, of subcontractors used a coordinated schedule to track and define 3 week and 6 week look ahead schedules, and weekly work plans along with the tracking of PPC. Feedback left from a survey participants stated:

“The downfall of our Pull Planning session was that the schedule produced was not consistently used and updated moving forward...”

“All trades were scheduled with adequate time to perform their work.”

“The process identified issues, but was not properly executed and followed through by the GC.”

“It allows for all trades to understand the flow of the work. Who was to work in what areas at what time? It also allowed to reduce the schedule as a team instead of being mandated by just one person on site?”

“I believe the impact was a positive one. However, changes took place in the field and it appears that we are now reacting to the changes, not planning for them.”

Table 2: Survey results of LPS implementation questions with data

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Project milestones were defined and communicated prior to the pull planning session	33%	44%	11%	5%	5%
2. Format of trade specific sticky notes was communicated prior to the pull planning sessions	33%	38%	16%	5%	5%
3. All necessary persons involved in the proposed milestones were present at the pull planning session	29%	17%	23%	11%	17%
4. The pull planning session resulted in a coordinated schedule and/or resolution of bottlenecks	27%	33%	16%	5%	16%
5. Coordinated schedule was tracked through 3 week /6 week look ahead with PPC	22%	38%	11%	22%	5%
6. The PPC was made available to all trades	44%	27%	11%	5%	11%

By not implementing the use of work plans and look ahead schedules based on the coordinated results of a pull planning schedule the information obtained, decisions made and commitments promised are not tracked and can lead to variation in the schedule. Such variations can be seen through field observations of Project #1, pull planning meetings resulted in some coordination of constraints that were never tracked and soon forgotten after the meeting. Through the observations of Project #1, weekly work plans, look ahead scheduling and regular PPC tracking schedule meetings assisted in the projects successful completion, though not on time there were many hurdles that were overcome quickly and effectively without high amounts of lag in the schedule. If the project team properly connects collaboratively built schedules and weekly work plans together subcontractor buy-in will increase.

In observations of Project #3, the coordinated schedule was managed through a “big room” atmosphere. Innovative practice at this jobsite is to utilize 'mobile' pull planning boards that stay on display in a dedicated room (Figure 3). There are (4) boards corresponding to 4 weeks allowing for a 4 week look ahead to be completed and on display for all project areas. After one week is complete it is cleared off and rotated to the back to be collaboratively updated during the weekly foreman meetings. Good traction for adoption with team has been noted. We conclude that the increased traction is because an already common task of 'look ahead scheduling' has been adapted to LPS and modified into a visual tool. The weekly look ahead pull planning is also part of typical weekly foreman meetings which were also a standard meeting. By making weekly work plans synonymous with the collaboratively built plan LPS

techniques have absorbed existing management procedures/habits and reduced perceived change resulting in high buy-in for this project team.



Figure 3: Picture of look ahead boards used on observed Project #3

When gathering comments from subcontractor trades involved with observed Project #1, they highlighted how the project team and staff was willing to resolve issues, identify constraints and take proactive actions to resolve the schedule variations. The implementation and consistent follow through of LPS on this project also allowed for transparency among trades minimizing labor risks, safety risks, rework and maximizing sub alignment. The overall coordination and collaboration of LPS did not completely keep the schedule from experiencing delays but allowed for productive acceleration without noticeable trade stacking.

ACCOUNTABILITY

The third element of LPS that is essential to success is PPC tracking. PPC is an essential equation of LPS, in terms of accountability. (Fauchier, 2013) When PPC is tracked properly and is available to all parties, the project team's focus is held on the schedule maintaining reliable workflows. Accountability should be held from the top down, from the owner to the second, third tier subs. When accountability is not present teams go through the motions, data becomes irrelevant and collaborators become followers. (Fauchier, 2013) Research observations suggest that transparency of commitments is an important technique to enhance accountability and reduce "sandbagging." When durations are negotiated among trades, realistic terms are created, tracked and individual workflows are identified along with necessary processes and non-value added waste, lag will diminish from the schedule.

Project #1, tracked PPC throughout the project via weekly work plan meetings and published the results to the entire team. The trust and communication between team members was very apparent. One example of this is when a mistake was made on a weekly work plan as far as an unfinished result, the subcontractor immediately recognized this and notified the Construction Manager of the variation in the schedule that this caused. Instead of feeling unable to communicate this to the Construction Manager the subcontractor trade trusted the team relationship, and looked to maintain their accountability. 72% of surveyed subcontractors reported PPC tracking on their projects. One survey participant responded, "All trades, including the General Contractor, made commitments and held each other accountable. When something unexpected did happen, everyone joined in to resolve the problem."

Project #2, was not tracking PPC. Delays were rampant through unanswered RFI's, submittals outstanding by at least 2 months and overdue inspections. There was low to no accountability on the project, which caused an impact to not only the schedule but the team morale. Subcontractor trades were not willing to commit to dates, or coordinated activities in pull planning sessions. Noncompliance notices were issued as subcontractors struggled to stay with the schedule and deal with the lag in the flow of information, causing rework and increased hostilities among the project team. Definition of PPC on this project would have allowed identification of bottlenecks and prompted collaboration to eliminate them.

Lack of accountability effects downstream material & labor resources. As seen on Project #2 this resulted in poor information flow, schedule/production flow, cost increases, increased rework, low or no team morale, no trust, and non-alignment of overall goals. In Projects #1 and #3, teams were willing to commit to dates and strived to beat the schedule when PPC was tracked and team members held accountable for their commitments. On Project #1, the schedule ran over by 6 weeks. The construction management team challenged the Subcontractor trades to reduce this to 3 weeks. As of March 2013 the subcontractors were able to meet this challenge through PPC tracking and achievable commitments from the construction management team, design team, inspectors and owner. Accountability harbors trust, pushes team ownership and collaboration which in return adds to improved production flow and schedule reliability. Accountability is essential for subcontractor buy-in for LPS and by extension the value added by LPS to the project.

IMPROVEMENT

None of the observed projects took a true look at the root cause analysis of uncompleted promises. This is an integral part of LPS to learn the trends of the project, and improvement opportunities. When continuous improvement is not in place, "5 Why's" are not used then your PPC has no context, no meaning (Fauchier, 2013). Common tools such as a "5 Why" Analysis assist in the PPC tracking to tunnel down to the true cause of a promise or commitment not completed and why. A simple answer of lack of labor could be a reason for not completing a task, but the true test is why was there not enough? Is this truly a coordination issue for the subcontracting company or is there an underlying issue. These are all questions that come from simply asking Why 5 times. When identified and tracked the root causes can lead to an understanding of the flow of the schedule.

Other forms of improvement include the analysis of the team's performance. How well did the team work together are there things that could be changed or processes that worked well that could be used in the future? These can be analyzed through Plus/Delta meetings held on the jobsite. The Construction Management team can learn how the implementation of LPS has affected the overall project through these comments from the construction team.

Improvement analysis is the most lacking element of LPS on projects. Through improvement analysis Construction Managers and Owners would be able to analyze their implementation efforts and the effects along with tracking the positive impacts and improving upon the negative impacts.

CONCLUSION

Through survey analysis and project observation our research has found that the top overlooked elements of LPS implementation include the lack of critical participation during pull planning sessions, proper identification of constraints, PPC tracking, and root cause analysis. Through the data analysis provided when any of these elements are not implemented subcontractor trade buy in to the overall project schedule and / or goal is minimal to none. When LPS is implemented properly subcontractor trade buy-in and collaboration flourishes enhancing overall project production.

The construction industry when compared to manufacturing faces many challenges due to variation. The most unreliable and varied component of a construction project is the schedule due to the coordination of multiple diverse workflows. These variations or defects can be identified and minimized by full implementation of The Last Planner® System. One of the biggest impacts of LPS is the human element of the construction team. “The Last Planner System is a great tool not only for General Contractors, Construction Managers and Owners, but also for subcontractors. (Fauchier, 2013)” As shown in our observations, survey and interviews when a Construction Management team implements LPS as a whole, the schedule is positively affected along with an effective team that strives for the same goals. When the LPS is not implemented completely subcontractor buy-in falters and the team will struggle to align interdependent workflows or increase productivity. When implemented properly and followed subcontractor trades buy in to the system allowing for a decrease in variations and a willingness to push towards the overall project goal. “When preparation meets opportunity, we have luck.” (Howell & Macomber, 2002). With “luck” we have a successfully executed project, on schedule and on budget.

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