LAST PLANNER® SYSTEM IS THE GATEWAY TO LEAN BEHAVIORS

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ABSTRACT

Participation in LPS teaches-by-doing such foundational behaviors as collaboration, transparency, long-term and short-term planning, making work ready, making clear commitments, reliable promising, accountability and metrics – all in a clear, living example of the colorful, visual workplace. LPS teaches teams the entire process of Plan-Do-Check-Act (PDCA) and PDCA becomes woven into trust-building, because using LPS (Planning) builds trust due to the making and keeping of reliable promises across siloed companies and through behaving (Doing) in predictable, transparent and monitored (Checked) ways and learning (Acting/Adjusting) together. Three main sets of behaviors related to or promoted by the LPS were identified: building social networks, addressing multiple needs in a dynamic environment, and treating construction projects as production systems. As a contribution, examples from construction projects implementing LPS are presented and linked to behaviors that emerge from LPS implementation. Examples illustrating the three behaviors reveal different instances in which these behaviors materialized and might have served as "a-ha!" moments for the teams involved.

KEYWORDS

Last Planner System, lean behaviors, action learning, collaboration, reliable promises

INTRODUCTION

The LPS was developed based on trial and error in practice and it elegantly addresses principles related to production theories and organizational management, which are discussed in this paper. This is a clear case in which practice has outpaced academia and great effort has been done over the years to assure that the theory behind the LPS is systematized. Much has been written about the LPS by practitioners and in academic fora, most of them related to Lean Construction research and implementation. While not explicitly discussed in academic papers, the LPS is viewed by some researchers and practitioners simply as a tool, as isolated components of the LPS system, or as a traditional planning method rebranded with LPS-related names. However, there is more theory behind the LPS than is usually recognized by many academics and practitioners. As a contribution to this discussion, this paper presents examples from construction projects which have implemented the LPS and links them to behaviors that emerge from LPS implementation.

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PROMOTING LEAN BEHAVIORS WITH THE LPS

Research in Construction Management is usually skewed towards scheduling and project controls given their contractual and operational importance to projects. However, in the past 20 years or so, a host of studies have addressed the importance of individuals and how they collaborate in construction projects (Laufer and Tucker 1988, Chinowsky et al. 2008) and how adaptive the managerial staff of a project (e.g., project managers, superintendents, foremen) has to be to match the environment in which construction projects are built and the needs of multiple stakeholders (Laufer et al. 1994). Another important subset of studies has addressed the need to treat projects as production systems (Koskela 2000). A brief literature review on these topics is presented to underscore how LPS promotes behaviors that fill gaps identified in previous studies, and ultimately promote lean behaviors. The authors do not intend to review the literature on LPS and would refer readers to papers published in the Planning and Control sessions of this conference (available at www.iglc.net).

BUILDING SOCIAL NETWORKS

With the intent of shifting construction project management's focus from the use of tools and detailed schedules to managing projects as social collaborations, Chinowsky et al. (2008) developed a Social Network Model for construction to highlight the importance of fostering communication amongst project participants. They stressed that "it is time to recognize the key role of individuals within project networks, including the communication and trust that is the basis for achieving high performance results" (Chinowsky et al. 2008, p.811). As individuals become more knowledgeable about each other's needs and constraints, the entire team becomes more knowledgeable and prone to deliver better performance over time.

Along the same lines, collaboration and active participation of multiple trades in the planning process is key for the successful implementation of plans. During meetings, participants can see their opinion is valued, and how important that is for achieving the project's goals as a team, and openly express their assessments before decisions are made. "Success of implementation is materially affected by the extent and manner in which the implementors were involved in the decision-making process" (Laufer and Tucker 1988, p. 343). The participation of foremen, superintendents, and other stakeholders during the LPS process is a trait that differentiates LPS from traditional planning methods which are grounded on the division of planning and doing. Shoet and Laufer (1991) observed that foremen of productive crews make time for planning. These foremen spend more time planning and viewing construction documents when compared to foremen of unproductive crews; the time they spend planning translates in better productivity in the field. This is in line with findings that show LPS improves productivity of crews (Wambeke et al. 2011), because foremen and superintendents in projects using LPS tend to be more involved with the planning process. Finally, once plans are implemented, a new set of knowledge arises from action and a new round of reflection and learning takes place among those involved with defining and implementing the plans. This happens when, in LPS, daily and weekly check-ins measure "Percent of Promises Complete" (PPC) and the root causes of missed commitments.

In addition to building social networks, LPS implementation often includes other behaviors that emerge in the deeply social environment promoted by the system:

- **Coaching, leadership, open participation (teamwork, collaboration, transparency), trust building.** Teams undergoing LPS implementation usually have some degree of coaching or leadership that emerges during the process. Collaboration and trust also emerge from LPS implementation. These behaviors are further fostered by a clear and visual workplace, which promotes transparency and information sharing among team members.

ADDRESSING MULTIPLE NEEDS IN A DYNAMIC ENVIRONMENT

Laufer et al. (1994) suggest that planning is a multi-faceted process which has to address multiple principles to be effective: 1. Hierarchy principle: "*numerous purposes for various users*"; 2. Comprehensiveness principle: "*numerous plans and various formats*"; 3. Continuity principle: "*numerous timings and various time horizons*"; 4. Cooperation principle: "*numerous participants and various modes of preparation*." LPS addresses such principles by promoting a continuous review of long/medium/short-range plans which are defined to match the information available during the time the plans are generated, involving stakeholders who are part the of value stream to deliver different phases of a project, and defining and communicating the plans in different formats (e.g., meetings, visual work environment). Also, part of this process is the Plan-Do-Check-Act (PDCA) nature of the LPS which promotes the continuous review of goals, plans, and results to promote continuous improvement and better match the project environment. This is especially relevant in complex projects (e.g., hospital projects discussed later in this paper) where the amount of effort spent on planning has to be adjusted to match the needs of ever changing and tightly coupled systems.

In the LPS environment, pull planning brings together the final client and internal clients of each major task, who are part of the effort to pull plan a schedule and make everyone in the project aware of how their tasks interrelate and impact client tasks. During the process, participants get rid of buffers that isolate tasks from one another and from the internal and external clients requirements in terms of timing (Ballard 2000). The work indicated in Weekly Work Plans (WWPs) represents a network of commitments which is founded on reliable promises made by project participants (Macomber and Howell 2003). WWPs are the result of project participants' work to build this network of commitments over time through different levels of the LPS. The constant definition, deployment and review of WWPs is a central element of the LPS, which pulls information from field operation to adjust plans and make changes. WWPs are essential to capture information that is available only after construction begins, e.g., weather, availability of resources, precise coordination, design clarifications, conflicts that might arise during production (Laufer et al. 1992)

In order to address the principles indicated by Laufer and Tucker (1988) the LPS also fosters:

- **Learning, continuous improvement and goal-driven behaviors –** formal and informal analysis of root causes and implementation of changes in short time intervals exemplifies these behaviors.
- **Systemic thinking/behavior –** the LPS fosters a systematic process that goes through a PDCA sequence and creates a stable sequence of tasks to be done in certain time intervals. Teams identify what the clients' need and value, define

work packages, define a work logic to create flow based on a network of commitments, screen tasks for constraints, make promises, implement plans, track plans to identify completed tasks and reasons for non-completion. This all-stakeholder systemic sequence promotes transparency and accountability week after week.

TREATING CONSTRUCTION PROJECTS AS PRODUCTION SYSTEMS

Lean construction implementation calls for a different look at construction projects as production systems to be designed and managed considering three essential aspects of production: transformation, flow, and value (Koskela, 2000). The **transformation** aspect deals with the efficient management of resources to deliver tasks as expected. The **flow** aspect promotes the view of construction as a network of interdependent tasks that need to be managed an integrated fashion to promote continuous generation of value to the client. The **value** aspect puts the project's client front and center and promotes the alignment of tasks to deliver what the client expects from the project.

To address these three aspects and promote the management of construction projects as production systems, the LPS diligently works to shield production against variation that might disrupt the flow of work (Ballard and Howell 1998). This diligent work to shield production against variation through a structured planning and control process yields good dividends.

Some production concepts embraced within the LPS include:

- **Use of pull and promotion of flow –** allows multiple stakeholders to translate their knowledge into plans that consider real time information, project participants' collective expertise and requirements.
- **Use of small batches –** the release of small and defined batches of work promote short cycles of detection and correction of problems, and higher quality.
- **Recognition of uncertainty and the need to continuously adjust planning** –metrics such as PPC and reasons for non-completion are tracked and analyzed to prevent the recurrence of problems.
- **Definition of clear production goals and metrics** – this clear definition of production goals help decision-makers establish plans that match actual resources available and makes everyone aware of measurable goals used to control execution.

METHOD OF ANALYSIS

The initial challenge for any project or organization wishing to launch a lean journey is how and where to start. The authors are a lean trainer/coach and an academic with considerable experience in the field who have studied first-hand how – both academically and practically – how projects and organizations throughout South America and North America approach this challenge. The authors have collaborated for several years and in their separate careers have deeply and continuously observed over five dozen projects and organizations, each over a span of months and years. The authors draw herein on those observations, citing specific examples.

In organizing the exposition of the paper, we have first identified three main categories of lean behaviors and identified specific behaviors in each. Then examples are iterated to illustrate how LPS enacts such behaviors in practice.

EXAMPLES OF LPS IN PRACTICE – BEHAVIORS RELATED TO OR RESULTING FROM ITS IMPLEMENTATION

Drawing on the author-coach's experience with fifteen teams on nine specific projects in Northern and Southern California between 2010 and 2013, below are actual project workplace examples illustrating the above lean behaviors. The examples are organized in three main categories set forth above.

I - BUILDING SOCIAL NETWORKS

1. Collaboration. Because LPS requires that each step of planning is done by all affected or typically involved foremen and superintendents (but also owners, designers, consultants) there is an inherent expectation of collaboration.

Project Study A – Airport Terminal – In the first session, the LPS coach initially encountered a group of trade foremen who had been under pressure to complete the facility and, according to the General Contractor (GC), had begun turning against each other demanding the GC give them first or exclusive access to many of the shared work areas. Literally on Day 1 of the LPS sessions, the nature of collaborative discussions occurring at the Milestone, 6-Week Phase Pull levels changed the relationships from confrontational to collaborative by focusing their attention on the process and handoffs, not personalities. This social realignment has been observed on many occasions when LPS is introduced late in a troubled project.

2. Identifying value to customers. While establishing clear goals may be an inherent characteristic of LPS, a consequential behavior that logically flows from this is identifying what is valuable to customers. The end goal or milestone is likely a valued item to the end user, but various interim goals are of value to other customers including trades. The very act of identifying predecessors and constraints to the start or finish of an activity in LPS defines value to owner of that activity – that person is a customer of the trade or organization performing the predecessor activity (or removing the constraint).

Project Study B – Medical Center – Although the multi-project medical center was still three years from completion, when the Virtual Design & Construction (VDC) director began orchestrating LPS Milestone pull sessions across the various projects (hospital, specialty medical office building, central utility plant and site/off-site) with the Owner's independent commissioning agent, the Last Planners found additional ways to drive value to the medical and maintenance end users by including them more directly in the sessions, exploring and clarifying their deeper long-term needs and taking the process far beyond what any of the parties had envisioned or contracted. The dialogs around "the milestone wall" led to this.

3. Open participation/communication, transparency – Transparency among Last Planners is essential to making reliable promises. In initial stages of implementing LPS, often the parties approach each other without much trust and "hold cards close to the vest". They begin the process without disclosing all assumptions and actual needs. As the process proves itself, trust increases, and with it transparency.

Project Study C – Public Middle School #1 – A small team of prime superintendent and Project Management (PM) and ten trade foremen initiated LPS sessions and met weekly. By the third week the plumbing foreman, initially quite resistant to "filling out stickies" began to disclose that the durations he had initially required could be shortened because he saw others performing as promised. When the Independent Inspector of Record began attending the sessions he disclosed that his required 48-hour notice could be reduced to 24 hours because he lived a few blocks away and could see transparently when work needed to be inspected to maintain project flow.

4. Trust building and reliable promising. While one could assert that reliable promising is an inherent characteristic of LPS, in fact, the authors have found that Last Planners do not necessarily begin making reliable promises. It is only when they experience the impacts of others not making and keeping reliable promises, that they begin to see the value in this practice.

Project Study C – Public Middle School #1 – The owner's representative began attending the LPS sessions for this Middle School and began observing that one of the things impacting the trades' meeting their commitments was lack of timely RFI responses. Recognizing the value of the process and the need for good workflow, she announced to the group that she would participate weekly, make out commitment tags describing when an RFI response was needed to release their work, and then deliver on her promises. She did what she promised, and went even further by bringing in the Inspector of Record and persuading him to make commitment stickies, too and further facilitate the flow of trade work.

II. - ADDRESSING MULTIPLE NEEDS IN A DYNAMIC ENVIRONMENT

1. Goal-driven behavior. The requirements of meeting commitments (promises) which each Last Planner makes in the Weekly Work Plan (WWP) results in behavior which drives toward the milestones/goals.

Project Study D – College Arts & Technology Centers – Having grown accustomed to Weekly Work Planning (WWP) and filling out tags and to weekly updates, PPC and variance discussions, an experienced LPS team found themselves falling into the habit of just bumping their missed commitments to the next day or week without consequence. The project completion date slipped. The success of LPS was questioned. But when the team began adding their milestones prominently to the WWP, and refusing to move the milestones, it forced them into devising ways to revise their work to still meet their milestone goals.

2. Making clear commitments (understood by all). Human beings are not accustomed to making clear commitments and Last Planners are no exception. When they write down a description of the activities they commit to perform, they are often sloppy in language and precision. When "a right to left pull" of activities and their associated predecessors and constraints is done by the LPS facilitator, often the predecessor is difficult to find because the two trades use different words to describe it. It is only then that participants realize that they must use words and descriptions that are clear and meaningful to everyone in the group. In so doing they also learn to make clearer commitments.

Project Study B – Medical Center – Completion of the communication nerve center (called a TER/TR) in a specialized area of a 12-story hospital involved a dozen

organizations, mostly prime to the owner. This specialized group had been meeting for weeks making large TO DO lists but not making real progress completing the work. A drop-dead date was only five weeks away. The group shifted to Phase Pull planning emphasizing iteration of predecessors and handoffs, clarifying what each commitment tag clearly included/excluded. As the end date approached, they shifted to a Weekly Work Plan with daily tags and began daily check-ins. The clarity of their commitments, expressed as daily tasks, allowed them to complete this critical nerve center one day early.

3. Systemic thinking and deep analysis of cause. Humans often jump to conclusions or rush to understand "why", mistaking symptoms for causes. Asking 5 Why prompts us to dig deeper. But often in construction the root causes are multiple.

Project Study E – Prison Medical Center – One-third of the way through the block wall construction on 15 housing units it was discovered that a critical penetration detail was being missed and would require substantial rework. This threatened to delay the fast-track, high-volume project and miss the delivery date. Moreover, it could give rise to the owner questioning what other crucial details might the team be incorrectly installing. Because the team had had such swift and early success with LPS, they inquired as to what other lean tool might be utilized to solve this problem and chose Root Cause Analysis. Countermeasures proved effective and the Owner was reassured the team was fully in control.

Project Study B – Medical Center – When the rate of passed inspections fell to 89%, missed inspections frequently resulted in WWP activity "misses" which rippled through activities on the Weekly Work Plans. "Inspections" had risen to third on the list of Variance Causes. The schedule, the planning system, and their reputations were threatened. Superintendents gathered to examine why they could not achieve the 95% goal. They looked to Root Cause Analysis to facilitate this inquiry, found the three main root causes for the problems and devised an entirely new series of counter-measures.

4. Learning and continuous Improvement. We learn from our failures. This team's tenacity in trying to get it right gives the term Continuous Improvement a new dimension.

Project Study D – College Arts & Technology Centers – The project buildings required that significant concrete pours occur for nearly a year before much other work could occur. Mechanical, Electrical and Plumbing trades had many blockouts and stubups that had to interface with massive concrete work. An initial token effort at pull planning was made but was ineffective. CPM drove the schedule. Significant delays by the concrete contractor were exposed as the root cause when, after a year of stumbling, robust LPS was introduced and behaviors (good and bad) became transparent. The contractor was fired. LPS continued with robust acceptance by foremen. However, the construction manager was found to be ineffective at achieving goals and when its contract expired, it was replaced. Again the trade foremen rallied and with a new CM again rebooted LPS, this time learning to use Milestone scheduling to establish the path to completion, then pulling from key milestones to plot detailed WWP activities and sequences. The tenacity of the foremen and attitude of continuous improvement prevailed. The project is headed toward successful completion – late, but on a date certain and reliable.

III. - Treating Construction Projects as Production Systems

1. Establishing clear production goals. LPS begins with clear customer goals – often expressed as one or, more often, many milestones.

Project Study E – Prison Medical Center – Halfway through a $640 Million prison hospital, project leaders had been relying on CPM and Short Interval Production Scheduling (SIPS), but needed to increase work-in-place from $1.5 Million/Day to $3 Million/Day. They implemented the Weekly Work Plan format for each of 27 housing units, 3 hospital buildings and a facilities kitchen. Because the clear long-term goal was "Start of Punch List" to occur in 18 weeks, they were able to engage 70 foremen and trade superintendents in a series of thirty 18-week detailed weekly work plans (the 4'x8' weekly boards covered 3 walls of a huge site trailer, then were tracked in Excel) with the clear end milestone framing a more innovative sequencing of the activities. They finished six weeks early.

Project Study A – Airport Terminal – With four months to Substantial Completion and three months behind in the construction of a major new airport terminal, the General Contractor implemented LPS and declared a clear short-term goal of Startup of Air Handler Unit #1 knowing that focusing on creating a conditioned space would release significant internal trade work. The team achieved the milestone within four weeks, then refocused to each of the remaining eight AHU's and finally to Substantial Completion. The project caught up the delays and finished on time.

2. Long-term and short-term planning. Properly used LPS is fully time-scale integrated.

Project Study B – Medical Center – At the construction start of a Central Utility Plant for a Billion Dollar medical center, the Superintendent implemented Last Planner System with Milestone Planning for the entire project, then a series of 8-week Phase Pulls to pull plan every step in the two year construction before construction began. A Senior Project Engineer entered all the information into SureTrak, which the Superintendent printed out and color coded to match the trade tag colors. For two years they used this completely pull-planned scheme to populate and continuously refine their Weekly Work Plans.

3. Promotion of flow and predictable handoffs between work stations or trades. LPS can help sequence in weeks, days or hours, as seen in this very large project.

Project Study B – Medical Center – In the earliest days of what would become three years of LPS implementation, the general superintendent and trade foremen working in a 40' deep pit installing piers atop caissons as deep as 90' needed to make up several weeks of time due to design complications. They broke the work down into trade/day sequences, first among a group of piers, then pier by pier and saw that the work had become so predictable, they could create per-pier stickies in hours, not days and sequence their work and handoffs hour by hour on each pier. Doing this they reduced the overall duration of that portion of the work by over four weeks.

4. Definition of clear metrics. Success can lull a team into lazy behavior. Metrics can be the wake up call.

Project Study B – Medical Center – Metrics matter: both a Hospital LPS Team and a Central Utility Plan LPS Team reached a point when their PPC (Percent of Promises Complete) was reliably in the 70-95% range and, at different times unrelated to each other, stopped tracking PPC. When their coach discovered this he

gathered the data from prior weeks, calculated PPC and showed them it had fallen to 55%. Not watching the "score" had created laxness and poor performance.

5. Promote flow and creating a clear, visual workplace. The clear visual workplace is an inherent characteristic of LPS: colored post-its.

Project Study F – Cardiac Research Center – Inspired by colorful milestone plans, phase plans, and WWPs on the walls of the large site trailer, the Superintendent of a premier Cardiac Research Center moved the WWP boards with all the colorful stickies out to the construction jobsite for 15-minute daily check-ins with yesterday's visual commitments marked off each morning. Workers could also see "the Plan".

Project Study B – Medical Center – Inspired by the multicolored stickies on their pull plans and Weekly Work Plan boards, several floor teams began devising how else they could make their workplace visual. They posted floor-specific WWPs on each floor, posted floor plans with a pad of colored post-its for any worker to post questions or issues to be tackled daily by the Superintendent. Colorful VICO Line of Balance reports began to be posted alongside the PPC and variance charts. The visual workplace began popping up all over, inspired by the multi-colored LPS stickies.

6. Small batching. We encourage designers and constructors to think of smaller batches in order to achieve maximum sequencing and flow of information and materials. Last Planners best learn this lesson as a consequence of using LPS.

Project Study G – Medical EMS Remodel – The Design/Build team was led by the Builder's PM and the Architect with 10 engineers, consultants and trades participating. The team had promised to cut the first of three phases of design from seven months to four. They used Weekly Work Planning with swim lanes adapted to design usage, with each entity having its own color tag, but placing those tags in the swim lane of the other entity needing their work. They learned that they did not need the full work product of another entity to release work of their own. "Just give me 'x'," they would say. Instead of large periods of non-activity followed by frantic activity, they were able to smooth the work flow by sharing information and drawings in small batches, completing not one but three phases in the first four months.

7. The value of flow. Trade foremen (the Last Planners) inherently understand the value of flow, as evident in initial training of foremen, whose faces express understanding of the goal of LPS when it is described as helping them to achieve flow. However, because in the broader world of design and construction flow is not frequently experienced, Last Planners' appreciation of the value of flow comes as a consequence of experiencing it after several weeks of using the WWP.

Project Study H – Public High School Campus – After three sessions of LPS planning, the project team realized that the plan for moving trades from one building pad to the next did not take into account the constraints at the edge of the property abutting the streets. Using pull planning, they tested and then resequenced the circular flow into a zig zag flow moving into areas as early as possible, accounting for constraints and still keeping the project moving.

Project Study I – Hospital and NICU Remodel – Within two months of his first experience of LPS, this 15-year superintendent described how the weekly collaborative conversations with his trade foremen more fully informed him on the value of letting them choose how to flow their work in concert with each other. The issues and challenges he said had previously kept him awake at night were now a

shared responsibility with his foremen, who knew better how, collectively, to achieve the flow he knew could be possible.

8. Identification of waste. Even value processes like LPS can be stripped of waste.

Project Study D – College Arts & Technology Centers – While identified waste is usually in our work, a team that had been through real difficulty but had virtually mastered LPS together and understood "pull" at all levels, challenged themselves to freshly pull the last 8 months of the two companion projects to see if time could be reduced. After a rigorous four-hour milestone level pull session, they decided that pulling at the 6-8 week phase level would be wasteful, and went directly to the Weekly Work Plan level and pulled from selected 6-week milestones.

FINAL REMARKS

Observation of fifteen teams on nine projects utilizing Last Planner® System has demonstrated how participation in LPS teaches-by-doing foundational lean behaviors discussed based on the literature review and the analysis of the projects. LPS is not just a tool. LPS is the gateway to the panoply of highly desired lean behaviors. This paper aimed to contribute to dialogue about the benefits of the LPS and how it promotes behaviors conducive to greater collaboration and improved performance of teams. Three main sets of behaviors related to or promoted by the LPS were identified: I. Building social networks, II. Addressing multiple needs in a dynamic environment, and III. Treating construction projects as production systems.

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