# A SURVEY ON THE LAST PLANNER SYSTEM: IMPACTS AND DIFFICULTIES FOR IMPLEMENTATION IN BRAZILIAN COMPANIES

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## ABSTRACT

The Last Planner System (LPS) has been the focus of several studies in the Lean Construction community. Many papers have reported its implementation in different types of projects around the world, and more recently some quantitative studies attempting to evaluate its impact have been published. This paper aims to evaluate the impact of the LPS from a different perspective. Instead of using performance measures, this study is based on the perceptions of people involved in the implementation of the Last Planner System in construction sites. A survey was carried out with a sample of construction companies from the South of Brazil. In each company, interviews were undertaken with representatives from three managerial levels: site engineers, foremen and crew leaders. The results point out different perceptions for each of those levels. While most benefits perceived by engineers and foremen are concerned with the planning process itself, crew leaders have emphasize the indirect benefits of the system, such as reliability of material delivery and site organization. Moreover, understanding the perception of the main people involved with the implementation of LPS provides some indications of what is often misunderstood about this system, making it possible to identify improvement opportunities.

## KEY WORDS

Planning, Production Control, Last Planner System, Impact, Perception.

## INTRODUCTION

A large number of construction companies have implemented lean concepts and practices around the world with the aim of improving project performance. Most of

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them have adopted the Last Planner™ for production control (Ballard 2000), often as an initial step that provides a basic stability (Smalley 2010), creating conditions for introducing more advanced lean ideas. In fact, at IGLC annual conferences, a large number of papers have reported the use of Last Planner over the years, providing evidence that this system have been successfully implemented in a large number of projects from different countries, such as USA, Brazil, Chile, Ecuador, England, Finland, Denmark, among others.

Although the Last Planner[7] System is well described in the literature (Ballard and Howell 1998; Ballard 1997; Ballard 2000), much needs to be discussed on the core ideas that are underneath this system. In fact, there is a continuing effort for further improving it, for instance, by integrating other managerial functions (Marosszeky et al. 2002; Saurin et al. 2004), extending to other managerial levels (Ballard and Howell 2003), and developing software tools that support its implementation.

Most research studies developed so far have emphasized the analysis of qualitative data, based on a small number of case studies. More recently, some studies have emphasized the importance of quantitative analysis in order to evaluate the effectiveness of the implementation of the Last Planner System as well as its impact. Papers from Chile (Alarcón et al. 2005), Colombia (Botero and Alvares 2005) and Brazil (Bortolazza and Formoso 2006; Formoso and Moura 2009) have been published on this matter.

However, there is very little systematic evidence on the impacts of the Last Planner System based on the perception of the people directly involved in production management, such as site engineers, foremen and crew leaders. It seems to be important to investigate how this system is understood by the last planners themselves, and what they think about its impact and barriers for full implementation.

The aim of this article is to assess the impact of the Last Planner System, based on the perceptions of people involved in production management at an operational level, especially those involved in the medium and short term planning meetings. It also seeks to analyze their perceptions on the difficulties for implementing this system. Two hypotheses were tested in this study: (i) the perception about improvements and difficulties changes according to the interviewee position; (ii) LPS brings some indirect benefits to production management, such as improving safety and eliminating waste.

This study was conducted in the Metropolitan Region of Porto Alegre, the capital of the State of Rio Grande do Sul, in the South of Brazil. It is based on a survey involving 12 construction companies and 20 construction sites.

## RESEARCH METHOD

The first step of this study was to identify companies in the region that have consistently used the Last Planner System in the last few years. A number of academics and consultants were contacted and, based on their knowledge, a group of 16 companies were selected.

Using a sample of construction projects, two types of data were collected:

[7] Last Planner is a Lean Construction Institute trade mark

(a) Interviews with site managers, foremen and crew leaders, aiming to collect their perceptions on the impact of the Last Planner System and on the difficulties that they have faced for implementing it;

(b) A metric on the degree of implementation of Last Planner, based on a check list of 15 planning and control practices (see Table 2). This metric, named planning best practice (PBP) index, has been used in a number of academic studies (Soares et al. 2002; Bulhões and Formoso 2005; Sterzi et al. 2007), and also by several construction companies involved in a Benchmarking Club carried out in Brazil between 2004 and 2007 (Formoso and Moura 2009).

## CREATING THE DATA COLLECTION INSTRUMENT

Before creating the data collection instrument, some semi-structured interviews were carried out with production managers who had several years of experience with LPS, who pointed out a set of important issues related to the implementation of the system, as well as its impact in project performance. Based on those interviews, the questionnaire was devised – this was divided into three parts.

In the first part, some data related to the implementation process were collected, such as how long ago implementation started, the main planning tools that has been used, and previous experience of the interviewee with LPS. Besides using the check-list of best practices, some specific questions were asked about master planning, which has the role of establishing what should be made in the Last Planner System (Ballard, 2000).

The second part of the questionnaire consisted of open questions about the most important positive impacts of Last Planner and the most important difficulties for its implementation, based on the perception of the interviewees. Data was reduced and classified into a set of categories for each type of information according to a previous classification adopted by Costa et al. (2005).

The third part of the questionnaire was focused on the impact of the Last Planner System implementation. The questions were developed and organized into six different headings, presented in Table 1, including impacts on waste reduction, workflow reliability. For each question, the interviewees had to answer whether the impact of LPS implementation was for better or for worse, and the degree of this impact, according to a Likert scale (from -5 to +5). If the answer was zero it meant that the interviewee perceived no change at all.

The questionnaire was validated in a pilot study, and was also reviewed by some production management senior academics. All questions were asked directly by members of the research team – if necessary some clarifications about the meaning of some expressions were made to the interviewees. Moreover, the Cronbach's Alpha statistical test was used to validate the questionnaire after the first 20 interviews. The resulting coefficient was 0.94, indicating that the proposed instrument had internal consistency.

Table 11 - Categories of the questionnaire

| Categories | Explanation |
|---|---|
| **Design** | Includes the availability of drawings for production, and the control over design changes. |
| **Planning** | Refers to changes in weekly plans, delays due to interdependency between activities, matching load with capacity, availability of materials and information, and cost deviation. |
| **Control** | It is concerned with production control issues, including adherence to the planned sequence and safety management. |
| **Manpower** | Related to commitment of the crews and productivity. |
| **External Issues** | Related to suppliers, as well as client interference. |
| **Wastes** | Related to some of the wastes in production such as transportation, waiting, overproduction, processing, making-do, inventory and defects. |

## Data Analysis

In order to do correlation analysis and analysis of variance, the scale was converted into positive values between 0 and 10. Therefore, it was possible to make a score rate for each group of questions and relate them to other variables. Pearson's Correlation associated with a *post-hoc* test using *Tukey* test criteria was used. For the correlation between discrete variables the Chi-squared test associated with the Fisher's exact test was used, due to the size of sample.

## RESULTS AND DISCUSSIONS

The sample that was selected for this study consisted of twelve companies from the Metropolitan Region of Porto Alegre. Seventy-five people from nineteen different construction sites were interviewed. The reliability level considered for the analysis was 95%, and the error was 14.6%.

On average, the companies had started implementing the system 7 years ago, ranging from more than 10 years to less than 3 years for the least experienced one. The PBP index was on average of 63.3%, ranging from 90% to 50%, indicating that the degree of implementation of the Last Planner System had a fairly wide variation between companies.

Table 12 shows the average score for each practice in 16 of the construction sites in study. The results confirm a similar profile of implementation of LPS compared to other studies (Formoso and Moura 2009; Bortolazza and Formoso 2006): most companies have successfully implemented what is recognized as the first step of implementation, i.e. routine, participatory weekly plans. However, they are not so successful at the look-ahead planning level: none of them have fully implemented systematic constraint removal.

Regarding the profile of the interviewees, the number of years of experience in construction sites varies from 6 months to 40 years. However the majority of the interviewees had less than 5 years of experience with the Last Planner System.

Table 12- Average score for each practice

| Practice | Average | Degree of implementation | | |
|---|---|---|---|---|
| | | Full | Parcial | None |
| Formalization of the planning and control process | 90.6 % | 13 | 3 | 0 |
| Standardization of short-term planning meetings | 87.5 % | 12 | 4 | 0 |
| Use of visual devices to disseminate information in the construction site | 84.4 % | 12 | 3 | 1 |
| Corrective actions based on the causes non-completions of plans | 81.3 % | 11 | 4 | 1 |
| Critical analysis of data | 81.3 % | 12 | 2 | 2 |
| Correct definition of work packages | 68.8 % | 6 | 10 | 0 |
| Systematic update of the master plan, when necessary | 68.8 % | 9 | 4 | 3 |
| Standardization of the medium-term planning | 65.6 % | 10 | 1 | 5 |
| Inclusion of only work packages without constraints in short-term plans | 65.6 % | 10 | 1 | 5 |
| Participation of crew representatives in decision making in short-term planning meetings | 62.5 % | 4 | 12 | 0 |
| Planning and controlling physical flows | 56.3 % | 3 | 12 | 1 |
| Use of indicators to assess schedule accomplishment | 50.0 % | 6 | 4 | 6 |
| Systematic removal of constraints | 40.6 % | 0 | 13 | 3 |
| Use of a easy to understand, transparent master plan (e.g. by using a line of balance) | 34.4 % | 3 | 5 | 8 |
| Scheduling a back-log of tasks | 21.9 % | 3 | 1 | 12 |

### PERCEPTION OF IMPROVEMENTS

The interviewees were asked what was the main improvement resulting from the implementation of the Last Planner System. As it was an open question, the data was classified into a set of categories, which are shown in Table 13.

The main improvement perceived was the possibility of visualizing the task to be carried out and the improvement of transparency in the planning process. Improvement in site organization was also one of the most cited categories – this includes both site safety and also the way teams were organized around the construction site. It was fairly surprising for the research team that this category received more citations than task control itself. This result corroborates one of the hypotheses of this study: LPS not only improves planning and control but also brings some indirect benefits to production management.

Task control and improved efficiency and control improvements also received a large number of citations. The improved efficiency category includes both raising productivity rates and waste reduction. Constraint removal received a fairly low number of citations, probably due to relatively low degree of success in the implementation of look-ahead planning among the companies involved in the survey.

The hypothesis that different professionals had distinct perceptions on the benefits of the Last Planner System was tested. However the chi-square test showed that there was no significant correlation between those variables.

Table 13 - Main headings of the perception of improvements

| **Main Headings** | **Answer** |
|---|---|
| Visualization of the future and planning transperancy | 26.2% |
| Construction site organization | 23.1% |
| Control over tasks | 12.3% |
| Increase in efficiency | 12.3% |
| Participation in the planning process | 7.7% |
| Constraints removal | 6.2% |
| Others | 12.2% |

### PERCEPTION OF DIFFICULTIES

Table 14 presents the perceptions of different professionals about the main difficulties for the implementation of LPS. In fact, there was a significant difference among the perceptions of those professionals, according to the Chi-square test associated with the Fisher's exact test (p-value=0.002<0.005).

The problems regarding to the adaptation to the new culture – from traditional, centralized, CPM based planning, to participatory, pull-driven LPS – was the main difficulty perceived, considering all categories. Personnel qualification was the second most cited considering all answers. That includes the shortage of labour that currently exists in Brazil due to the boom that is happening in the construction industry.

Based on the Tukey test, there was a significant difference in the perceptions between engineers and crew leaders (foremen cannot be considered a third group, they have a perception similar to both groups - p-value=0.026<0.05). Engineers were the only group that felt they ha to spend too much time in the planning issues. By contrast, foremen considered as the main problems the adaptation to the new culture and, especially, personnel qualification. A large percentage of crew leaders mentioned that they found no problems in the implementation of LPS. However, this category was the only one who emphasized the problem of interdependences between tasks as a major difficulty. This might be related to the fact that PPC is often used as an indicator to assess the level of commitment of subcontractors. In that case, a delay on a previous task can affect the PPC of the following subcontractor.

Table 14 - Main headings of the perception of difficulties

| | Total | Engineer | Foremen | Crew Leader |
|---|---|---|---|---|
| Adaptation to the new culture | **26,9%** | 36,0% | 20,0% | 16,0% |
| Personnel Qualification | **20,9%** | 16,0% | 32,0% | 8,0% |
| Too much time spent on planning issues | **9,0%** | 24,0% | 0,0% | 0,0% |
| Lack of information | **4,5%** | 8,0% | 4,0% | 0,0% |
| Interdependence among processes | **4,5%** | 0,0% | 0,0% | 12,0% |
| No answer | **17,9%** | 4,0% | 16,0% | 28,0% |

### PERCEPTION OF CHANGES AFTER IMPLEMENTING THE SYSTEM

Figure 10 presents the perception of interviewees about the impact of Last Planner on production management. Problems concerned with design and external issues were the ones that had the lowest impact, according to the interviewees. It means that the impact of the Last Planner System on suppliers' reliability, client interference, design changes, and drawings availability seem to be lower compared to planning and control related problems. However, 95.5% of the interviewees were more satisfied with the Last Planner System than the traditional planning and control system they had used before.

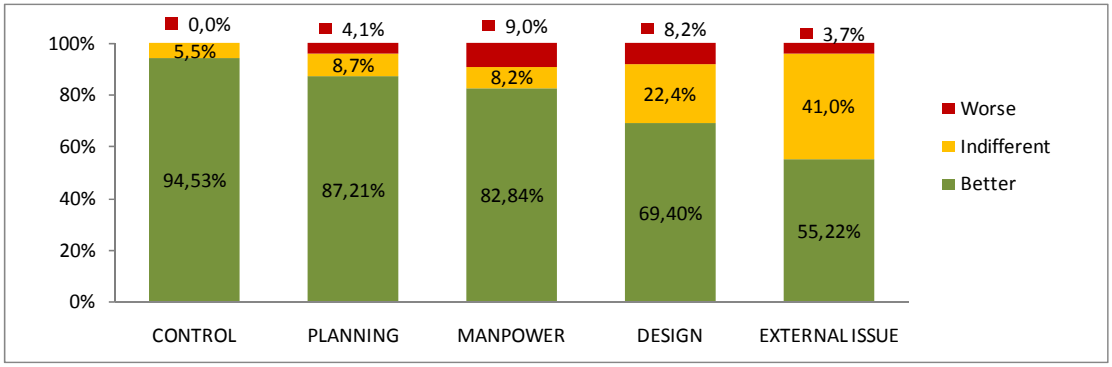


Figure 10 - Perceptions about the changes after Last Planner Implementation

Based on post-hoc Tukey tests, the perceptions of the different categories of interviewees were compared. The analysis of variance indicated that, for a significance level of 5%, the perceptions about the improvements vary according to the category of interviewee, for three issues: planning (p-value=0.007<0.01), control (p-value=0.003<0.01) and manpower (p-value=0,013<0.05).

Besides, each category was analyzed by using a Chi-squared test associated with Fisher's exact test, not considering the interviewees grade, but just the perception of a change for better, a change for worse, or no change at all, after LPS implementation.

Despite the design category have not had a significant relationship between the grade and the position, the question about the drawing availability showed a high significance level (p-value=0.001<0.01). While the engineers perceived a change for worse, the foremen perceived it for better.

Regarding planning related benefits, there was a significant difference between site engineers and crew leaders, although neither of those groups were significantly different from foremen perceptions. Regarding control related benefits, site engineers had a different perception when compared to foremen and crew leaders, which did not have a significant difference between them.

Manpower related benefits had a similar pattern to planning benefits: site engineers and crew leaders differ from each other but are not significantly different from foremen perception.

Those results pointed out a general trend that site engineers and crew leaders have different perceptions about the benefits of the Last Planner System. In fact, the perception of the researchers, during the interviews, was that foremen were the ones that had more knowledge about the way the planning and control process was being carried out. In some sites their perceptions were closer to the site managers', while in other sites to crew leaders.

## PERCEPTIONS ABOUT THE IMPACT OF LPS ON PRODUCTION WASTE

In this part of data collection, the seven categories of waste, proposed by Ohno (1988) were used. An eight category, named making-do, suggested by Koskela (2004) was also considered. In the pilot study, one of the categories of waste, movement, was removed from the survey, because the interviewees found difficult to compare the amount of movement that existed before and after the implementation of Last Planner. It means that the interviewees found difficult to compare movement (as an operation) before and after system implementation.

The questions about the perception of waste were made in an indirect way, avoiding problems related to that lack of understanding of the concept of waste. For example, the question asked to assess the impact on making-do was: "after the Last Planner System implementation, what is your perception about ensuring that a task begins only when all the necessary conditions are available for its conclusion". So the interviewee had to answer according to a scale if he perceives a better, or a worse change. Figure 11, presents the perception of the interviewees about the impact of Last Planner on the reduction of waste.

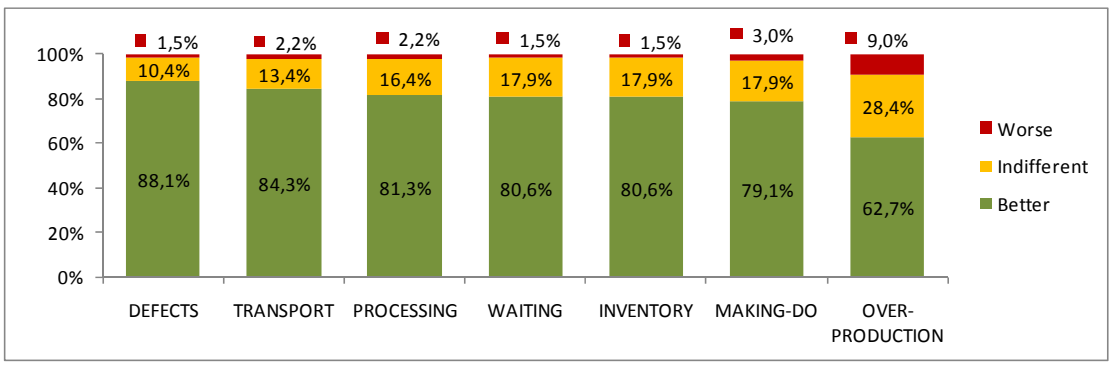


Figure 11 - Changing perception regarding wastes

For all categories of waste, the interviews perceived improvements. The overproduction category of waste was the one that had the lowest impact on the perception of the interviewees. In fact, during the interviews the research team noticed that people did not understand how it could be bad to have more production than what was planned. This fact suggested that, despite the fairly good degree of success in the implementation of LPS, there was a lack of awareness about the problems created by work-in-progress. Moreover, it seems that work packages are not really regarded to what should be done, according to the master plan.

An analysis of variance was made in order to check whether there was a difference between the perceptions of each professional category regarding the impact of Last Planner on waste reduction. Based on a post-hoc Tukey test, for a significance level of 5%, site engineers had different perceptions compared to foremen and crew leaders. Based on Fisher's exact test there was evidence (p-value=0.017<0.05) that foreman perceived a change for better for the **making-do** waste, in relation to the other categories. The perceptions about **inventory** waste indicated that engineers had a higher level of indifference than it was expected (p-value=0.039<0.05). Also, the crew leaders perceived a change for worse related to the **processing** waste while engineers were indifferent in relation to this category (p-value=0.025<0.05).

## CONCLUSIONS

This study consisted of a survey on the impacts and difficulties for implementing the Last Planner System, in which two main hypothesis were tested. The conclusion was made that the perception about improvements achieved could not be related to the professional category, indicating that everyone had a similar point of view. However the perceptions of difficulties in the implementation of LPS change significantly according to the interviewee position. While site managers believed that the adaptation to the new culture and the time spent on making the plans was the main difficulties, the foremen perceive that the major difficulty to deal was concerned to personnel's qualification. The crew leaders were the only group that cited the problem of interdependence between the activities.

The second hypothesis was related to LPS indirect improvements, which was corroborated by the high rates of change for better perceptions in all groups of questions. The interviewees considered that the implementation of the system had improved site conditions, reduced waste and improved safety.

Another important conclusion is that 95.5% of the interviewees had the perception of improvement of the overall production management system. They also emphasized as positive the higher degree of participation in the planning system, reinforcing the importance of the planning meetings in the effectiveness of the Last Planner System. Regarding waste, there was a perception of improvement for all waste categories, except for overproduction. This seems to be strongly related to the fact that most interviewees are not aware of the impacts of this type of waste.

Although the high level of the system implementation in the companies and the perceptions that it had a positive impact on the production management, it seems that some of the key ideas of LPS are not fully understood. The survey indicated that some traditional excuses for low performance, such as workers qualification and the lack of commitment of subcontractors are still considered by several managers as the most important problems, instead of giving attention to root causes of planning failures.

Moreover, some site engineers keep complaining that they spend too much time in planning. It seems that is important to understand the limitations of the LPS in terms of implementing Lean Production, although it plays a key role in creating the conditions for achieving the basic stability that is necessary for implementing some further steps.

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