PERFORMANCE IMPROVEMENT PROGRAMS AND LEAN CONSTRUCTION

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ABSTRACT

The paper examines the relationship between Lean Construction and Performance Improvement programs in construction organizations. The authors argue that the structure and focus of existing performance improvement programs are a barrier to Lean Construction's entry into the organization.

The paper first analyzes the characteristics of successful performance improvement programs, and develops a model that identifies three critical elements: 1) Time Spent on Improvement, 2) Improvement Skills and Mechanisms, and 3) Improvement Perspective and Goals.

The authors identify different ways to "structure" the improvement program: outcome focused (such as Critical Success Factors) and process focused (such as Lean Construction). The paper discusses the implications of the different "perspectives" and argues that they lead to different improvement approaches each reflecting different paradigms for the nature of the change. The authors propose that "result-focused" improvement programs may be a barrier to the adoption of Lean Construction.

KEY WORDS
Lean construction, Implementation, Improvement programs

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INTRODUCTION

Improving organizational performance is a complex and dynamic process. Technical, organizational and human factors interact over time even as the variables change. The literature on improving construction performance identifies several methodologies for improvement (productivity studies, TQM, benchmarking, etc.) as well as factors affecting the success of improvement programs (such as senior management commitment, skills, teamwork, incentives).

This paper moves beyond these individual factors and proposes a dynamic model of the performance improvement process. The model emphasizes the interaction of several organizational factors and behaviors and their effect on the intensity and long-term success of the improvement effort. It also identifies feedback mechanisms that play an important role in the process.

The model identifies three essential elements for the success of performance improvement effort:

(1) Time spent on improvement,
(2) Skills and Mechanisms for improvement, and
(3) The Focus and Goals of the improvement effort—result-focused (such as the critical Success Factors) or process-focused (such as Lean Construction)

The authors argue that the "focus and goals" of the improvement program lead to different approaches to improvement, and have different ability to address complex production problems and drive long-term improvement. The paper also suggests that due to the different approaches to improvement, result-based programs are a barrier to Lean Construction's entry in an organization.

DEVELOPMENT OF THE MODEL

The model proposed in this paper is a conceptual framework that identifies the organizational variables (or factors) that influence a company's ability to improve its performance. Such factors include organizational resources (e.g., time), performance goals, work load, skills, performance levels, motivation, etc. The model illustrates the dynamic interaction of these variables. The goals of the model is to help managers and change agents:

- better understand the conditions that facilitate and obstruct the improvement process, and
- identify actions and policies that can make the improvement process more effective.

The model is presented as a causal-loop diagram (Forrester 1961, Sterman 2000). Causal-loop diagrams were developed in system dynamics modeling to illustrate cause-effect relations and feedback loops. The systems dynamics approach has been used to analyze a variety of social, economic, ecological, and organizational systems.

The proposed model variables and cause-effect relationships have been identified in the following sources:

- Construction literature. For example, the literature on the application of Total Quality Management (TQM) in construction proposes factors required for the success of the improvement efforts. Burati et al. (1992), list seven fundamental elements that support TQM: management commitment and leadership, training, teamwork, statistical methods, cost of quality, supplier involvement, and customer service.

- Systems dynamics literature. Keating and Oliva (1999) developed a dynamic model of performance improvement in product development. Their work provided one of the points of departure for this research.
- Experience. Direct involvement in and observation of the performance improvement process in construction projects and organizations. Discussions with managers and personnel directly involved in the improvement process, and observations of performance improvement programs

The model presented in this paper captures some essential elements of the improvement process, and provides a starting point for a more complete "picture" of the issues involved. However, it has the following limitations:

- First, the model is not "complete." Other variables and causal loops that are not presented here, may also affect the process,.
- Second, the variables have not been "operationalized." In the following sections, the authors explain what the variables mean in practice, but the variables have not been specified to the point that data can be collected to test the proposed relationships. Again, the goal of the model is to provide a conceptual framework for better understanding of the improvement process.
- Third, the model does not quantify the strength of the relationships between variables. The relationships described are qualitative.
- Finally, the model had a limited validation, primarily through feedback from other professionals involved in the improvement process in their organizations.

Thus, the proposed model can be considered as a set of "hypotheses" for further testing.

CAUSAL MODEL OF THE PERFORMANCE IMPROVEMENT PROCESS

Figure 1 shows the key factors that determine the success of the improvement process. The model is depicted as a causal loop diagram and illustrates the interactions between the key factors.

An arrow between factors means that factor X affects factor Y. A positive sign indicates that if factor X **increases**, then factor Y also **increases**. A negative sign indicates that if factor X **increases**, then factor Y **decreases**. A double line indicates a time lag. When more than one arrow converge to a diamond, then ALL of the conditions need to be present for the resulting factor to occur. For example, (1) "Time Spent on Improvement", (2) "Skills and Mechanisms", and (3) "Perspective and Goals" must ALL be present for effective "Operational Improvements" to occur.

The development of "Operational Improvements" depends on three key factors:

- "Time Spent on Improvement"
- "Performance Improvement Skills and Mechanisms," and
- "Perspective and Goals"

"Operational Improvements" are the changes the organization implements. These improvements result in "Improvement Results" but with a time lag.

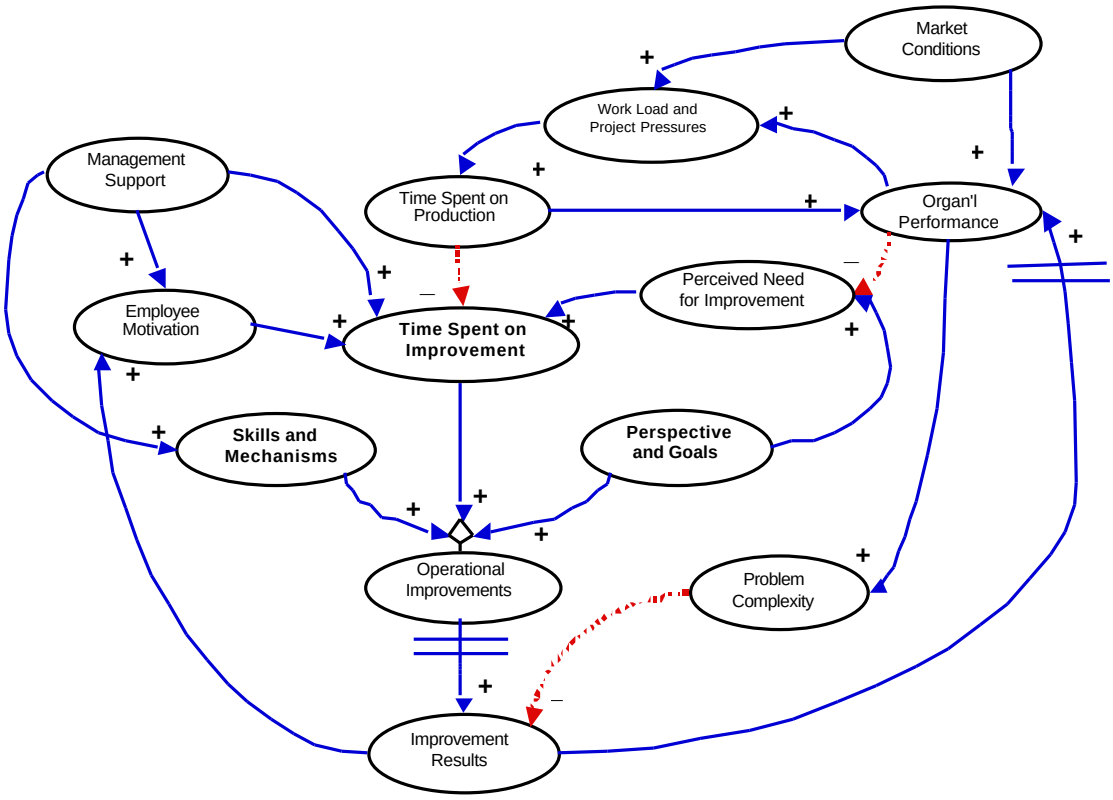

FIGURE 1. MODEL OF PERFORMANCE IMPROVEMENT PROCESS

1. "TIME SPENT ON IMPROVEMENT"

1.1 "Time Spent on Production" reduces "Time Spent on Improvement". The "Work Load and Project Pressures" increases "Time Spent on Production." "Market Conditions" increase the "Work Load." Because of the increased volume of work, and the difficulty to hire qualified people in a growing market, project staff is spread "thin" and cannot allocate much time to improvement. The "Time Spent on Production" increases the "Organizational Performance." This illustrates the managerial dilemma between " today's performance" vs. the "future performance."

1.2 "**Management Support**" increases "Time Spent on Improvement." The construction literature considers senior management support critical for the success of the improvement effort. "Management Support" is indicated by the following: (a) Personal involvement in improvement efforts. (b) Acknowledging and rewarding the efforts and successes. (c) Hiring employees who can contribute to improvement. (d) Evaluating middle management (project managers and superintendents) based partially on their contributions to improvement efforts, and (e) Providing resources for training and bringing in external experts as needed. Management commitment is also reflected in the approach to risk taking and experimentation.

"Management Support" also increases "Employee's Motivation." Employees are less likely to be involved in an improvement effort if their supervisor does not support their involvement. Many supervisors discourage their subordinates to spend time on improvement because it diverts employee attention from "real work."

1.3 "**Employee Motivation**" increases "Time Spent on Improvement." In every organization there is a (typically small) percentage of employees who are actively looking for ways to improve the work and initiate improvements. These are the "champions" who put a lot of personal time in improvement. Another group of employees is willing to try new ideas even if they don't make any particular effort to initiate changes. And finally, there is group that is not interested in improvement.

"Improvement Results" increase "Employee Motivation" (a) if efforts and successes are acknowledged and rewarded, and (b) if the positive results come fast. If the results take a long time, the participants' motivation is reduced. However, many of the complex production problems may have a longer time lag between the start of the improvement effort and the result (the easy/fast solutions typically have small effect and do not bring substantial change). Both management and employees involved in improvement process need to understand this.

1.4 "Perceived Need for Improvement" increases "Time Spent on Improvement." The "Perceived Need for Improvement" is the gap between the "Organizational Performance" and the target performance. Thus, "Organizational Performance" reduces the "Perceived Need for Improvement." Good "Market Conditions" increase "Organizational Performance". In a good market (when the work volume and profit are good) managers perceive less need for improvement even without equally good operational performance. Furthermore, in a market where the demand is high, the project budgets have higher contingencies, which reduce the pressure for high process performance. Finally, "Improvement Results" increase "Performance" thus reducing the "Perceived Need for Improvement", as they reduce performance pressures.

The "Need for Improvement" is directly affected by the "Perspective and Goals" of the improvement process. First, the improvement goals create a pressure for improvement when the gap between goals and performance widens. Thus, managers can increase the "Perceived Need for Improvement" by setting high performance goals. Benchmarking against "world-class" companies is one example. However, it is not only the **level of goals**, but also the **type of goals** that generate need for improvement. Even more important, the managerial perspective (and mental models) of the construction process affect the interpretation of the root causes of the problems. This issue is discussed later under "Perspective and Goals."

2. "PERFORMANCE IMPROVEMENT SKILLS AND MECHANISMS"

2.1 Performance Improvement Mechanisms. The mechanisms for learning can be grouped in three categories (Garvin 2000).

(i) Learning from Experience. Such mechanisms include observation and analysis of existing processes (office or field), after action reviews, and any methods for review and evaluation of organizational activities. Work methods improvement developed systematic approaches to analyze production operations (Parker and Oglesby 1972, Oglesby, Parker and Howell 1989).

(ii) Gathering Intelligence. Another way to identify potential improvements is by monitoring the external environment. This includes exploring developments outside the company, keep up with new designs, methods and technologies that take place outside the company.

(iii) Learning through Experimentation. Experimentation includes using new untested methods and techniques. These could be production technologies, management methods (e.g., Last Planner), new information systems, incentives systems, etc. Two important issues related to experimentation are: a) the extent that management supports risk taking (otherwise, no real risks will be taken), and b) how can we reduce/better control the risk involved in construction experiments? (e.g., it may be necessary to team-up with owners to conduct some experiments).

The use of learning mechanisms increases the organization's ability to identify problems and improvements. However, the ability to identify effective changes also depends heavily on the available skills.

2.2 Performance Improvement Skills. Every performance improvement process includes three major steps:

(i) Acquiring information, when the organization collects measurements, observations, and data (such as statistical data of defects, market data, productivity data, etc.)

(ii) Interpreting information, when the organization analyzes the data to understand what it means, and what are the cause-effect relationships at work, and what are the real causes of the observed data.

(iii) Applying the information, when the organization develops and implements improvement initiatives.

To perform these steps effectively, the organization needs skills in acquiring relevant and meaningful information, as well as skills in analyzing the information, and creating effective changes. Skills in Process Analysis, and Root Cause Analysis are essential in order to discover the key factors affecting the performance, and develop effective interventions. Without such skills, solutions tend to address symptoms near the problem, rather than the root causes.

"Management Support" is essential for the development of "Improvement Skills and Mechanisms" as they provide the resources for development of improvement skills (through internal training or external experts), and the forums for intelligence gathering, after-action reviews, and process analysis. Furthermore, experimentation directly depends on the extent that management supports risk taking.

3. "IMPROVEMENT PERSPECTIVE AND GOALS"

The term "Perspective" refers to whether the improvement process is Result-focused or Process focused. The Critical Success Factors is an example of a "Result-focused" approach. Critical Success Factors are those result areas (such as Schedule, Safety, Estimating, Quality, Cost, Change Management, etc.) that directly affect the performance of the organization. TQM and Lean Construction are "Process-focused." The different focus of the improvement process has important implications for the direction of improvement efforts as it leads to the following differences:

3.1 Different goals regarding what the improvement teams are trying to accomplish. Result-based goals are typically oriented towards customer expectations. For example, the schedule improvement goals in a result-focused approach is expressed as "Complete all project on or ahead of the promised schedule," vs. "Reduce cycle time of process X" from

a process-focused perspective. The quality goal may be "Zero Punchlist at time of completion" (result-focused) vs. "Eliminate Defects and Rework" (Process-focused).

Result-focused goals and process-focused goals are both needed, but at different organizational levels. At the strategic level, management needs to establish result-focused strategic improvement goals in the areas that are critical for competitiveness (such as schedule and cost reduction, safety and quality improvement, etc). But in order to meet the strategic improvement goals, the improvement efforts need to focus on the production processes. Traditional management systems do not focus on production processes, but are result-oriented. However, a "results attitude" emphasizes fixing problems and fighting fires, rather than preventing problems, planning and learning (Lareau 2000).

The key point is that result-focused goals emphasize results with or without process improvement. Such goals have limited effect on "Perceived Need for Improvement" when the results are satisfactory. On the other hand, process-focused goals continue to drive process improvement even if the project results are satisfactory. Anderson and Cook (1995) suggest that management must focus on process improvement first and results second.

3.2 Different perspectives regarding the root causes of performance problems. The simple truth is that when there is no explicit focus on the process, the direction of improvement efforts is determined by the prevailing mental models of the participants. The prevailing perspective (mental model) in construction considers project work as a collection of "activities" rather than a flow (Koskela 1992). People who hold this perspective believe:

- The sources of the problems are "outside the process"—the owner makes changes or adds scope, the design is incomplete, the subcontractors were late, did not provide manpower when needed, etc.
- Performance problems are typically attributed to individual factors, such as responsibility, motivation, and skills, rather than systemic factors (such as how the work is managed, coordinated, etc.)
- Delivering a project is just like "skinning a cat." There are a thousand ways to do it, all pretty much the same.

Process-focused approaches (such as TQM and Lean Production) emphasize both the components of the process (activities, crews, etc.) and the interdependencies between the components of the complex production system (Howell 1999). The sources of the problems are "inside the process"—interdependence and variation, and the incentives, behaviors, and work rules that generate and propagate them. Consequently, the different perspectives lead to different directions of the improvement efforts. In other words, the definition of the problem drives the "solutions."

4. "OPERATIONAL IMPROVEMENTS"

Depending on the "Time Spent on Improvement", "Skills and Mechanisms", and "Perspective and Goals," the amount and type of operational improvements varies.

Result-focused programs are more likely to focus on responsibility and accountability, skills and motivation. Applied in a general contractor organization, these programs lead to greater emphasis on contractual clauses (allocate responsibility), pushing the contractors harder (hold them accountable), training the project personnel in identification of defects,

or increasing the efforts (e.g., having more inspections earlier). Similarly, subcontractors may focus on workers' skills, and efficient equipment. This perspective usually does not aim to change the way the work itself is done, rather it changes the context within which work is done.

By contrast, process-focused efforts emphasize the interdependencies between the process participants, requirements and the work processes themselves. This leads to very different solutions. The example in Table 1 illustrates the solutions that result from the different approaches to quality improvement.

TABLE 1. Approaches to quality improvement

	Result focused	Process focused
Goal	Zero Punchlist at time of completion	Eliminate defects
Causes	• Defects not identified earlier • Incorrectly installed work • Damaged work	• Defects not prevented • Incorrectly installed work • Damaged work
Emphasis on:	• Subcontractors Responsibility • Inspections	• Work Process design
Improvement initiatives	• Do more inspections earlier • Causal analysis limited to identifying who failed and must repair work. • Train employees to identify defects • Discuss with subs the importance of zero punchlist, motivate, reward subs • Include clauses for work protection • Backcharge for damaging other trades work	• Assure processes are under control. • Root cause analysis–5 "why's" • Understand level of quality is needed/wanted by "customer" • Effectively communicate quality requirements • Sequence work to reduce schedule pressures and damages • Better manage trades interdependencies • Change the work method, process, and tools.

Result-based improvement efforts may even increase the "waste" in the process (e.g., by adding inspections, and increasing tracking of defects, rather than reducing waste by preventing defects). Finally, the different perspectives also lead to different participation in the improvement process. Result-focus efforts do not lead to continuing cross-functional or cross-organizational efforts because they do not emphasize the interdependencies between the process participants. Cross-organizational cooperation is typically limited to project-level initiatives, but there is no long-term cooperation between contractors, designers and owners to continuously improve work processes.

5. PROBLEM COMPLEXITY

"Problem Complexity" reduces the improvement result (assuming that the perspective and skills remain the same). The problems that the improvement effort addresses have different levels of complexity. Simple problems involve few organizational units/functions and have a simple methodology. An example of a simple system is a crew that performs a relatively simple operation under conditions of low variability, e.g., painting. There is only one organizational unit involved (the painting crew) and the operation has few steps. The factors affecting the performance are relatively few and easily identified (e.g., crew skills, tools and equipment, etc.) The impact of such changes is immediate.

The complexity of the problems increases as the number of organizational units and their interactions increase, and as the number of steps required and their variability increases. For example, the construction of foundation includes layout, excavation, forming, rebar installation, concrete pour, and stripping the forms. This is a relatively complex operation that involves several different organizational units, and multiple steps and interactions.

Improving performance of complex operations requires cross-functional (or even cross-organizational) changes in the way the work is organized and managed (in term of sequence, interdependencies, technologies, incentives, control mechanisms, etc.). Thus, complex problems require a process focus and cross-organizational effort. As a result, as the problem complexity increases, it becomes harder to achieve improvement results.

6. IMPROVEMENT RESULTS AND FEEDBACK LOOPS

"Improvement Results" increase "Organizational Performance"—although with a time lag (for example, the results of training will be observed in later phases or following projects). The improvement results also increase employee motivation as well as management support, which leads to spending more time on improvement. This creates a positive feedback loop.

On the other hand, when the organizational performance increases, the work load typically increases because the organization is more successful in getting more work. In addition, the perceived need for improvement also declines. Increased work load and reduced need for improvement reduce the time spent on improvement. Thus, a negative feedback loop is created that "regulates" the process.

"Organizational Performance" increases "Problem Complexity"—that is, as the organization performance increases, further improvements require solutions to more complex problems. Effective improvements are harder to identify and implement, with fewer and slower improvement results. This creates another negative feedback loop. This means that if improvements are based on training, motivation, and extra work load (such as additional inspections), the organization will have to increase its efforts simply to maintain the same level of performance. However, when improvements are incorporated in the work processes (rather than the people or inspections) they can be sustained with less effort.

CONCLUSIONS

The paper proposed a dynamic model of the performance improvement process. The model examined the factors affecting the process and their interactions. The paper proposed (a) that the direction of the improvement effort is strongly influenced by the

structure and goals, and (b) that result-focused programs have limited ability to address complex systemic problems.

One question for future research is what drives a contractor to establish a result-focused or a process-focused program. It appears that specialty contractors are more familiar with the process-perspective because of their familiarity with productivity improvement studies (which is a process analysis of a relatively simple problem). On the other hand, general contractors are more likely to emphasize overall project results.

Future research also needs to (a) develop and validate a more complete model of performance improvement, (b) further examine the behavior of the improvement process over time, and (c) use the model as a starting point for system redesign by "adding loops" and "breaking links " (Senge et al. 1994).

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