

COMPETING CONSTRUCTION MANAGEMENT PARADIGMS

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Abstract

The Lean Construction Institute's (LCI) goal is to develop and deploy a new way of thinking about and practicing project management. Projects are conceived as temporary production systems, to be designed in light of the relevant 'physics' of the task to be accomplished. It is claimed that complex, quick, and uncertain projects cannot be managed in traditional ways. Detailed CPM schedules, after-the-fact tracking, earned value analysis, and competitive bidding are inadequate to the challenge of today's dynamic projects.

There are four roots of this Lean Construction approach: success of the Toyota Production System, dissatisfaction with project performance, efforts to establish project management on a theoretical foundation, and the discovery of facts anomalous (impossible to explain) from the perspective of traditional thinking and practice. The last of these four is explored in this paper, which presents the current state of construction management thinking as one of conflict between competing paradigms.

Keywords: construction management, flow, lean construction, paradigm, production system, project management, theory, value, variability, work flow, work flow variability, work structuring

Introduction

Lean Construction can be understood as a new paradigm for project management. Thomas Kuhn's famous account of how science develops through periodic conceptual revolutions (Kuhn, 1962) also describes the change from mass to lean manufacturing, and the parallel change from traditional to lean project management. According to Kuhn, periods of revolutionary change begin with anomalies that the established paradigm is unable to explain, leading eventually to the development of a competing, and ultimately victorious new paradigm. One of Kuhn's well known examples: the Copernican revolution changed cosmology from geocentric to heliocentric at a time long before empirical tests could decisively settle the question because the traditional paradigm had become clumsy and convoluted.

Lean Construction had three initial sources of inspiration, the impact of which has been bolstered by dissatisfaction with the practical accomplishments of project management. Koskela (1992) challenged the industry to apply the principles behind the revolution in manufacturing, and quickly initiated an effort to establish production management on a

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sound theoretical foundation. The third source took the form of an anomaly discovered by Ballard (Ballard & Howell, 1998); namely, that normally only about 50% of the tasks on weekly work plans are completed by the end of the plan week. This proved to be an uncomfortable fact for a philosophy of project management that relied on detailed, centralized planning and the assumption that what SHOULD be done could be transformed into DID through contract structures and contractual enforcement.

This paper proposes to view Lean Construction as a new paradigm challenging traditional thinking about construction and project management. A section on the historical and theoretical background is presented first, followed by sections on the pivotal anomaly, sections presenting current phenomena in construction management from a Kuhnian perspective, and finally speculation regarding what happens next.

Background

What are the key characteristics of Lean Construction? First of all, it conceives a construction project as a temporary production system dedicated to the three goals of delivering the product while maximizing value and minimizing waste. Koskela has explained in detail how this differs from the traditional conception of a production system which sees only the single objective of product delivery; i.e., fulfilling contractual obligations (Koskela, 2000). This is also quite different from conceiving a construction project as an investment made in expectation of return, which while not entirely inappropriate, abstracts away from the messy business of designing and making².

Designing and making products the first time is what construction projects are all about and puts them firmly in the same class with other project based production systems; e.g., shipbuilding, movie production, software engineering, consumer product development, etc.

This production management approach to projects brings with it some key concepts, among the most important of which are value, flow, and pull. Value is understood as a production concept, not an economic concept. Consequently, expressions like 'value for the money' are replaced with expressions like 'value is provided when customers are enabled to accomplish their purposes.' Value in this latter sense has no necessary connection to cost.

Flow, the movement of materials and information through networks of interdependent specialists, is almost invisible to those who see through the eyes of traditional project management. We all were educated to see resource utilization. Are workers busy? Are crane hooks loaded and swinging? But we were not educated to see work flow; e.g., to understand the various types of buffers, to select the right type of buffer for a given situation, and to locate and size those buffers to perform their tasks of absorbing variability and rebatching. One of the contributing factors to this myopia may well be the inability of individual project participants to act at the level of the entire project.

Parker and Oglesby brought industrial engineering into construction with the publication of their *Methods Improvement for Construction Managers* in 1972. However, their focus was on the individual operation, on the activities performed to transform materials and

² One of the interesting areas for future exploration is the relationship between the conceptualization of projects in terms of economics and in terms of production. This is both a theoretical and a practical question: Can projects be structured such that the pursuit of product delivery, value maximization, and waste minimization is in the business interests of all parties?

information into desired products. Consequently, many of us have had the experience during our careers of improving the performance of individual operations, but not improving the performance of the project. We were acting on the specialist, but not on the flows between specialists.

Those flows vary. Things arrive early or late. The production of output of the same sort takes more or less time. This variability makes it difficult to match load and capacity; i.e., to prevent work waiting on workers and to prevent workers waiting on work. Consequently, productivity and progress are impacted by work flow, even if construction methods are adequate.

Toyota developed pull mechanisms in response to this problem of work flow variability in manufacturing. Kanban cards were used to signal supplier workstations to deliver needed items, rather than pushing inventory onto the customer workstation whether or not it was needed. When load is placed on a specialist based on the project schedule, without regard for the readiness of the specialist to perform that work or for the readiness of the work to be performed, that is push, which is the characteristic mechanism employed by traditional project management; for example, when detailed master schedules are used as control standards. By contrast, when assignments are required to meet quality criteria for definition, soundness, sequence, and size, as in the Last Planner system (Ballard, 2000b), that is an instance of pull. Pull is also used in the form of backwards pass team scheduling (Ballard, 2000a), which produces phase schedules intermediate between milestone master schedules and the make ready process with which production control begins.

The anomaly

Traditional project management assumes that variability in work flow is outside management control and so does not attempt to systematically reduce variability. Rather, contingencies of various sorts are used in an attempt to accommodate or absorb this external variability within the limits of budgeted time and money. An additional, implicit assumption is that variability is spasmodic and small, making it more plausible that its effects can be absorbed through budget and schedule contingencies.

In 1993, Howell, Laufer, and Ballard published two papers quite outside the normal bounds of the construction management literature. In the first (Howell, et al., 1993a), the central concept was the combined impact of work flow variability and dependence, and their implications for the design of operations. The central concepts in the second paper (Howell, et al., 1993b) were uncertainty in project ends and means.

In 1994, Ballard and Howell (Ballard, 1994; Ballard and Howell, 1994; Howell and Ballard, 1994a and 1994b) began publishing measurement data on work flow variability. The first data showed a 36% plan failure rate; i.e., 36% of assignments on weekly work plans were not completed as planned. Later publications (Ballard and Howell, 1998) expanded the data set, revealing a 54% grand average plan failure rate over a wide range of projects and project types.

This data represented a paradigm-breaking anomaly for traditional project management. Variability was in fact not spasmodic but persistent and routine. Neither was it small. What's more, analysis revealed that the large majority of plan failures were well within contractor control, contradicting the traditional assumption that variability was from external causes. The failure of traditionalists

to actively manage variability became visible as a failure, as did the corresponding need for active management of variability, starting with the structuring of the project (temporary production system) and continuing through its operation and improvement.

Table 1: Work Flow Reliability Data (from Ballard and Howell, 1998)

Contractor 1	33 %
Contractor 2	52 %
Contractor 3	61 %
Contractor 4	70 %
Contractor 5	64 %
Contractor 6	57 %
Contractor 7	45 %
Average	54 %

Talking through each other

Kuhn said that advocates for competing paradigms typically 'talk through each other' because they are each operating within their own paradigms (Kuhn, 1972, p.109). That appears to be happening in the field of construction management today. For example, a recent criticism of lean construction³ interprets the expression 'reliable work flow' to mean that the same amount of work is performed by construction crews in successive time periods, then finds contradictory data on examination of actual projects, and advocates a return of research focus to resource productivity as opposed to work flow reliability. The primary defense of the Lean Constructionists is that the concept is misinterpreted and that the critics are flogging a dead horse. There is no intent to reinitiate that debate here, but rather to see it as an instance of 'talking through each other'.

Disagreements over terminology are the natural consequences of competing paradigms. Let us consider in that light some terms central to the discipline of project management; namely, project, management, and control.

Project

We have already seen that the opposing camps have different conceptualizations of a project. Adherents of the old paradigm conceive a project in terms of delivery in conformance to contracts, neglecting waste minimization and value maximization goals. Failure to agree on the very object of study offers little prospect of agreement on anything else. Cursory examination of some other key concepts substantiates that expectation.

Management

The competing concepts of management can be expressed in terms of Johnson & Broms' (2000) dichotomy between Management-by-Results (MBR) and Management-by-Means (MBM). MBR would have managers establish financial targets and monitor performance

³ That Lean Construction is drawing fire is perhaps an indication that it is beginning to be perceived as a threat)

against those targets. Financial measures are used to evaluate and correct production processes. MBM would have managers create and maintain the means or conditions for sustained organizational performance, relying on process measures for feedback on system performance. Johnson and Broms present Toyota as one of the exemplars of MBM, suggesting that the 'lean thinking' originating with Toyota has roots and implications well beyond manufacturing management alone.

MBR conceives management as consisting of goal setting before the act of production, monitoring during the act of production, and correcting after the act of production. The MBM concept of management by contrast has production system design before, system operation during, and improvement after the act of production, with operating itself divided into goal setting, controlling (in the active sense of steering), and correcting (see also Koskela, 2001).

Control

Traditionalists conceive control in terms of after-the-fact variance detection, while the Lean Constructionists conceive control in terms of active steering of a production system or project towards its objectives. This can clearly be understood as a consequence of the MBR and MBM concepts of management. Some in the Lean Construction camp are now questioning whether after-the-fact measurement will any longer be needed if production system design and operation are mastered.

Changing common sense

Following Kuhn, we should also expect to see a change in what counts as common sense. Kuhn illustrates that with an example from the heliocentric/geocentric conflict, noting that there was no need to explain why bodies fell toward the earth as long as the geocentric view prevailed, along with the Aristotelian notion of essences or natures. Things made of earth naturally sought the earth, while things made of fire naturally went upwards. A fundamentally different concept of matter and of ontology underlies the seemingly unrelated shift from an earth-centered to a sun-centered view of the cosmos.

An example of common sense from the Traditionalist camp of project management might be the following claim: If we do every bit of work as soon as possible, we will finish the project as quickly as possible. Lean Constructionists note that the truth of this common sense claim depends on the patently false assumption that the bits of work are independent. Traditionalists might reply that they very well understand dependence and in fact encapsulate dependence in CPM schedules. This provokes a rebuttal from the Lean Constructionists and the dance goes on as long as the participants have the energy to continue arguing. Common sense from the Lean Construction perspective might be illustrated with the rule that we first go for plan (work flow) reliability, then go for speed; reminiscent of the ancient fable of the tortoise and the hare.

Will lean construction be victorious?

Not all challengers to existing paradigms successfully seize the crown. What should we expect for Lean Construction? Bearing in mind that the authors are wildly prejudiced on this issue, we venture the opinion that Lean Construction will displace Traditional thinking about project and construction management.

There are many bits and pieces that together may prove persuasive, though, of course, time will tell. First of all, existing project management thinking is not theory based. Indeed, some Traditionalists appear to believe that project management cannot be founded on theory because the decisions of project managers are so much conditioned by context. In this regard, the theoretical foundation advanced by Lean Construction clearly has the upper hand. If a theory-based alternative can be shown to be plausible, it will ultimately be embraced. The alternative is to be restricted to a craft-type discipline, in which one can only learn from a master, who can only show what to do in specific circumstances, but cannot explain why what is done is effective.

A preponderance of evidence will potentially shift the weight of 'public' opinion (the relevant stakeholders in the discipline). That evidence is building rapidly. For examples, see the proceedings of the annual conferences of the International Group for Lean Construction at www.vtt.fi/rte/lean. Lean Construction is now an active force in the United States, United Kingdom, Denmark, Finland, Australia, Brazil, Chile, and Peru. Implementation also has begun in Singapore, Indonesia, Ecuador, and Colombia. Consider but one example: Graña y Montero, one of the largest engineering/construction

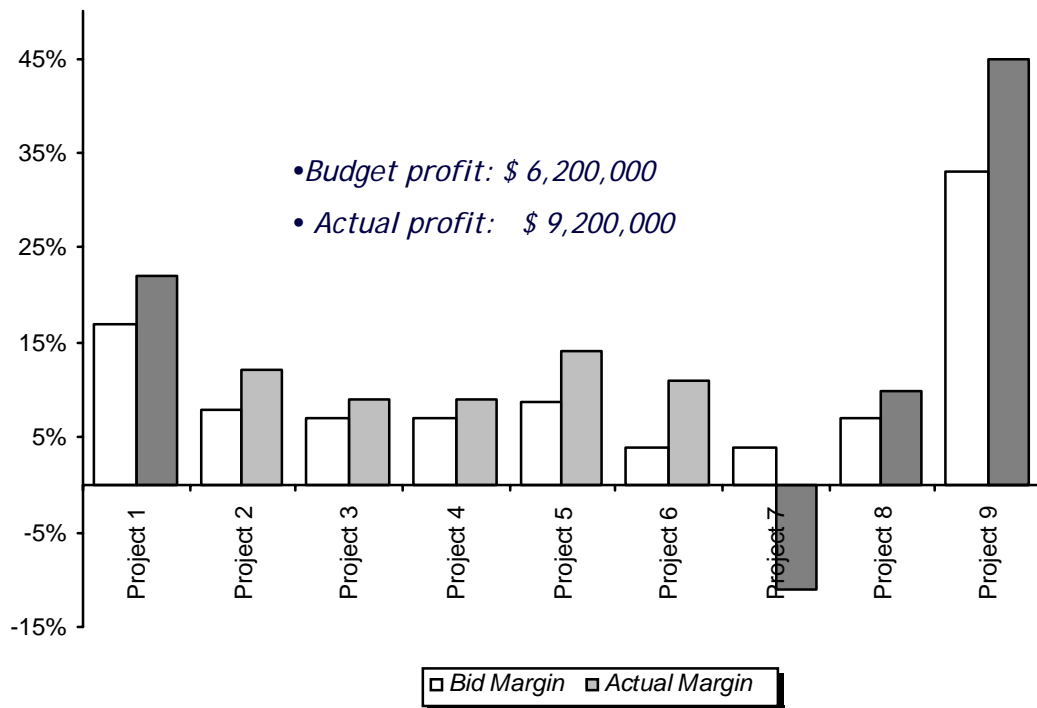


Figure 1: GyM Profitability Improvement⁴

contractors in Peru. Figure 1 shows the actual versus estimated gross margin (operating profit) on the first nine projects on which they employed a Lean Construction approach. Profit increased by \$3 million, from \$6.2 to \$9.2 million. This is but one example of many. Performance measurement is revealing the same magnitude of improvement as seen in

⁴ from a GyM presentation to the Lean Construction Institute at their AID Project in Lima, Peru in July, 2001.

earlier revolutions in production thinking; e.g., the Ford System in the 1910s and 20s and the Toyota Production System in the 1970s and 80s.

Success in the market is a key factor in the ascendance of technological concepts and techniques such as Lean Construction. The Lean Construction Institute has been working for several years with a small number of member companies, helping them develop their business capabilities while advancing its own research agenda. These companies, and others implementing Lean Construction tools, have shown significant success in their marketplaces. For examples, see reports by industry practitioners made at the Lean Construction Institute's annual Congresses at www.leanconstruction.org.

What happens next?

Looking at the situation through Kuhnian eyes, we can expect continuing clashes of the paradigms, a progressive ascendance of the new paradigm as it extends its critique of the old, demonstrates its theoretical and practical power, and gains adherents. Most of the old guard will retire or die like Joseph Priestly, the famous chemist who, despite his brilliance and contributions to chemistry under a previous paradigm, was never able to accept the new oxygen-based theory of combustion (Kuhn, 1972, p.56).

Dismantling the old paradigm will continue the onslaught begun with attacks on detailed central planning, after-the-fact variance detection, the earned value method of progress measurement, competitive bidding, and private ownership of the means of variability management; i.e., buffers such as schedule and budget contingencies, inventories, and capacities.

Numerous research projects are underway around the world on a variety of lean construction topics, some developing the paradigm, while some are of the "problem solving" variety Kuhn associates with "normal science":

- multiskilling
- learning to work near the edge (safety)
- management of continuous flow processes
- lean design of fabrication processes
- reducing lead times for engineered-to-order products
- structuring work for value generation
- target costing
- worker control of operations to process design versus managerial control of operations to budgets
- controlling work flow in design
- minimizing negative iteration in design

This trend appears set to accelerate as lean construction concepts and questions become better known. As we are led to expect from the history of such revolutions in other arenas, the young (in spirit) are in the front lines, while those successful under the old paradigm lag behind, clinging to the assumptions and methodologies that made them successful.

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references

- Ballard, Glenn (1994a). "The Last Planner." Northern California Construction Institute Spring Conference, Monterey, CA, April, 1994.
- Ballard, Glenn (2000a). "Phase Scheduling." White Paper #7, Lean Construction Institute, April 27, 3 pp.
- Ballard, Glenn (2000b). *The Last Planner System of Production Control*. PhD thesis, Dept. of Civil Engineering, University of Birmingham, Birmingham, U.K., June, 2000.
- Ballard, Glenn and Gregory Howell (1994). "Implementing Lean Construction: Stabilizing Work Flow." Proceedings of the 2nd Annual Meeting of the International Group for Lean Construction, Santiago, Chile. (Available in *Lean Construction*, A.A. Balkema Publishers, Rotterdam, Netherlands, 1997.)
- Ballard, Glenn and Gregory Howell (1998). "Shielding Production: Essential Step in Production Control." *Journal of Construction Management & Engineering*, ASCE, New York, NY, 124 (1) 11-17.
- Howell, Gregory and Glenn Ballard (1994a). "Lean Production Theory: Moving Beyond 'Can-Do'." Proc. Conference on Lean Construction, Santiago, Chile. September, 1994.
- Howell, Gregory and Glenn Ballard (1994b). "Implementing Lean Construction: Reducing Inflow Variation." Proc. Conference on Lean Construction, Santiago, Chile. September, 1994.
- Howell, Gregory, Alexander Laufer, and Glenn Ballard (1993a). "Interaction Between Subcycles: One Key To Improved Methods." *Journal of Construction Engineering and Management*, ASCE, 119 (4).
- Howell, Gregory, Alexander Laufer and Glenn Ballard (1993b). "Uncertainty and Project Objectives" in *Project Appraisal*, 8, pp. 37-43. Guildford, England: March, 1993.
- Johnson, H. Thomas. and Bross, Anders. (2000). *Profit Beyond Measure: Extraordinary Results Through Attention to Work and People*, Free Press, New York, NY.
- Koskela, L. (1992) *Application of the New Production Philosophy to Construction*, Technical Report 72, CIFE, Stanford University, Stanford, CA, September, 75 pp.
- Koskela, L. (2000). *An exploration towards a production theory and its application to construction*. Espoo, VTT Building Technology. 296 p. VTT Publications; 408. WWW: <http://www.inf.vtt.fi/pdf/publications/2000/P408.pdf>
- Koskela, L. (2001). "New Footnotes to Shingo." Proceedings of the 9th Annual Conference of the International Group for Lean Construction, National University of Singapore, Singapore. 12 p.
- Kuhn, Thomas (1962). *The Structure of Scientific Revolutions*, 2nd ed. International Encyclopedia of Unified Science, University of Chicago Press. Paperback, 210 p.
- Parker, Clarkson and Parker, Henry (1972). *Methods Improvement for Construction Managers*. McGraw-Hill, New York. 300 p.