THE JOURNEY OF LEAN CONSTRUCTION THEORY: REVIEW AND REINTERPRETATION

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ABSTRACT

The theory supporting Lean Construction has been developing since the early 1990s. The result is a set of conceptual foundations, fundamental principles, basic practices and a more or less common vocabulary. These developments challenge the foundations, principles and practices of traditional project management. The lack of a coherent underlying theory of traditional project management in three areas has led to the current problems in the construction industry. Lean Construction is an innovation that was provoked by the inability of traditional practice to solve a set of common and repeating problems on projects. Lean Construction has evolved and developed from Koskela's seminal work. He proposed a coherent theory that applied concepts and practices from Toyota Production System.

This paper traces the journey of Lean Construction theory from its inception by drawing on the work of leading thinkers such as Koskela, Ballard, and Bertelsen and then looks forward to the emerging field of complexity theory and its relationship to projects. The aim here is to explain key developments in theory of Lean Construction and where it is headed.

KEYWORDS

Lean Construction theory, complex systems, project management, and Cynefin framework.

INTRODUCTION

> "All change, even very large and powerful change, begins when a few people start talking with one another about something they care about."(Margaret Wheatley 2002)

Lean construction has been evolving over the last 20 years with theoretical foundations identified in Koskela's 1992 report. The report captured Lean Construction research agenda of as follows:

> *"Current academic research and teaching in construction engineering and management is founded on an obsolete conceptual and intellectual basis. It is urgent that academic research and education address the challenges posed by the new philosophy. The first task is to explain the new philosophy in the context of construction. Formalization of the scientific foundations of construction management and engineering should be a long-term goal for research."*

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Since then a group of likeminded academics and professionals frustrated by their experience with traditional project management have discussed this new philosophy. That approach, focused on contractual relationships and scheduling had a poor delivery record in terms of time, cost and quality. The underlying principles developed by Koskela are summarized below. (Koskela 2000)

Table 1: Production Principles

Main principles	Associated principles
Transformation view: Realize value-adding activities efficiently	Decompose the production task. Minimize the costs of all tasks.
Flow view: review the share of non-value adding activities	Compress lead time Reduce variability Simplify Increase transparency Increase variability
Value view: improve customer value	Ensure requirement capture Ensure customer requirements Take requirements for all deliveries into account Ensure production system capability Measure value

LOOKING BACK

The research papers presented at meetings of the International Group for Lean Construction between 1992 and 2000 focused mainly proposing that the construction industry should embrace production principles and techniques to managing projects and set aside the tired theoretical constructs of the conversion model. The Lean Construction community argued that there is a better way to manage projects. The proposed new model was synthesised by Koskela from the three principles in Table 1. This was the birth of the T-F-V theory of production.

Table 2: Production Principles

Subject of theory		Relevant theories
Project		Transformation Flow Value generation
Management	Planning	Management-as-planning Management-as-organizing
	Execution	Classical communication theory Language/action perspective
	Control	Thermostat model Scientific experimentation model

In 2004, Koskela and the second author challenged the traditional project management community by declaring the underlying theory of project management obsolete. This exposed the poverty of the theory espoused by the Project Management Institute and called for a reform. (Koskela & Howell 2004)

Thus the theoretical development of lean construction metamorphosed into a theory of the project (TFV) and a theory of management-planning, execution and control. This usefulness of this model is its ability to assist the construction industry in delivering projects and resolving conflicts arising from novel ideas from outside the industry.

LOOKING FORWARD

The journey of Lean Construction is still incomplete. Two developing lines of thinking, "complexity" exemplified in the Cynefin model of sense making and Dekker in relation to safety, and theories of collaboration and fairness proposed by Bowles and others may reshape, alter or expand the conceptual foundations of Lean Construction.

COMPLEXITY

Bertelsen and others propose that construction projects can best be understood as near the boundary between Complicated and Complex as described in the Cynefin framework. (Kurtz 2003). A long quote from Bertelsen provides an overview: (Bertlesen 2003)

> "*One important issue is the understanding of construction from a complexity point of view – a completely new and very challenging approach. This will inevitably bring the co-operation between the participants in the form of an integrated but temporary human system – not least the cooperation on the workers' level on the construction site – into focus as well. Modern management theories such as management as learning and management by walking around should be considered in the context of managing the construction process. (Bertelsen 2002 - Bridging the gap-towards a comprehensive understanding of lean construction)*
>
> *Even though Koskela's TFV-process model is very useful in understanding construction and construction project management (Koskela and Howell 2002, Bertelsen and Koskela 2002), the construction process is not the only way of looking at construction. It can also be seen as an industry which provides autonomous agents to undertake the project in question (Bertelsen 2002a), just as it can be seen as a social system – a cooperation between individuals and groups brought together for the project (Tavistock 1966). This paper thus introduces these two new perspectives and uses them along with the process view in analyzing construction as a complex system. (Bertelsen (2002) arguing about the need to view construction as a complex system)*
>
> *Complexity seems to provide a fruitful new understanding of the construction process and in should thus be an inspiration to new approaches to project management: organizing, planning, and controlling the process. However, the understanding of complex systems in construction calls at the same time for further research.*
>
> *One such area would be a deeper understanding of complex systems theory in relation to construction. Another area would be the use of modern business management principles in construction, not least on the*

> *cooperation on the construction site. Also closely monitored and analyzed experiments within project management based upon the management principles outlined above would provide useful new knowledge. Bertelsen (2003) - Complexity-Construction in a new perspective.*
>
> *While the transformation-flow-value theory broadens the understanding of project management, the perception of construction as a complex phenomenon opens up for the introduction of completely new approaches to project management. The ordered approach which gave rise to what can be called management-as-planning and management-as-organizing should be reinterpreted and supplement in future project management. Management as co-operation and as learning comes into focus. Indeed a huge challenge! (Bertelsen and Koskela- Construction beyond lean: a new understanding of construction management 2004)"*

Sidney Dekker offers a complementary view in his recent book, "Drift Into Failure".

> "*There is something really important that knowledge cannot tell us, and that is how a number of different things and processes act together when exposed to a number of different influences at the same time."* (Dekker, 2011)

He observes that barriers, as the boundaries of professional specialisation, policies, procedures, protocols, redundant mechanisms and structures add to a system's complexity. He postulates that in order to understand a complex system, it is advisable move up and out of the system to see how the system fits in the larger network of other systems.

Snowden and Kurtz developed the Cynefin framework below about 13 years ago to understanding how to act in situations with different levels of complexity based on recognizing different types of cause and effect relationships. (Kurtz 2003)

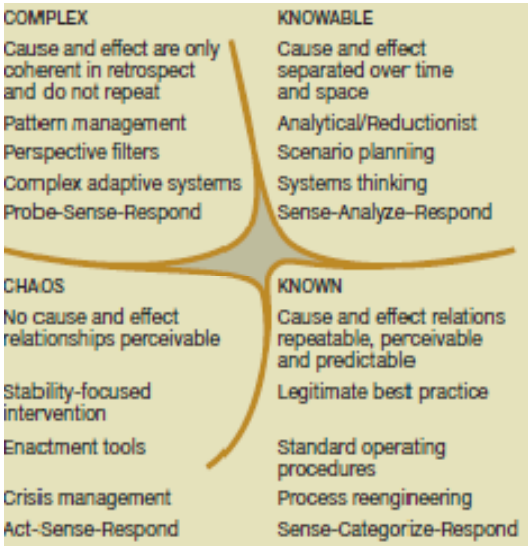

Figure 1: Cynefin Model

Four of the domains—systems and their associated environmental factors/systems—are simple, complicated, complex, and chaotic. The fifth domain, pictured in the center, is disorder. The simple and complicated domains are closer to ordered than

unordered. Complex and chaotic domains are unordered. The conceptual approach the Cynefin framework is grounded in questioning the universality of the three basic assumptions that pervade the practice of decision-making and policy formulation in organizations: 1.The assumption of order; 2.The assumption of rational choice; and 3.The assumption of intentional capability. Kurtz and Snowden described these assumptions as follows:

> ***"The assumption of order:*** *that there are underlying relationships between cause and effect in human interactions and markets, which are capable of discovery and empirical verification. In consequence, it is possible to produce prescriptive and predictive models and design interventions that allow us to achieve goals. This implies that an understanding of the causal links in past behavior allows us to define "best practice" for future behavior. It also implies that there must be a right or ideal way of doing things.*
>
> ***The assumption of rational choice:*** *that faced with a choice between one or more alternatives, human actors will make a "rational" decision based only on minimizing pain or maximizing pleasure; and, in consequence, their individual and collective behavior can be managed by manipulation of pain or pleasure outcomes and through education to make those consequences evident.*
>
> ***The assumption of intentional capability:*** *that the acquisition of capability indicates an intention to use that capability, and that actions from competitors, populations, nation states, communities, or whatever collective identity is under consideration are the result of intentional behavior. In effect, we assume that every "blink" we see is a "wink," and act accordingly. We accept that we do things by accident, but assume that others do things deliberately"*

How does Cynefin connect to the development of Lean Construction theory? The authors believe helps decision makers understand how their systems stands in the external environment and provides them with a framework to align understanding. In this regard, the Lean Construction community can use the model to make important distinction about the state of knowledge. It helps decision makers understand what kinds of methods and tools will be likely to work in our particular situation, and those that are unlikely to help. The Cynefin concept provides key insight that most construction professionals have likely ignored:

- The boundaries between simple, complicated, complex and chaotic are indistinct. Consequently, changes in external conditions or internal system modifications may push a given system or the understanding of it, from one domain to another without notice.
- Aspects of a larger system may inhabit more than one domain simultaneously.
- The spatial relationship among the domains emphasizes how easily (or insidiously) an organization might slip from one domain into another, possibly without noticing it.

- The boundary between complicated and complex is less distinct than the boundary between the simple and the chaotic. Consequently, the failure of management to recognize a shift from complicated to complex, while a problem, is not likely to be as catastrophic as the failure to recognize a shift from simple to chaotic. But all domains are directly exposed to the zone of disorder. This should prompt leaders to pay attention to their system's relationship with its environment.
- Simple and complicated domains assume an ordered universe, where cause-and-effect relationships are perceptible, and right answers can be determined based on facts.
- Complex and chaotic domains are unordered. There is no apparent relationship between cause and effect.

Revisiting the Lean Construction theory in light of the Cynefin framework poses challenges. Projects range from simple, slow and certain – painting a simple wood fence – to those that are complex, uncertain and quick – designing and building hospitals. Cynefin provides those working in projects to assess the circumstance and take actions appropriate for the situation and those studying projects to be clear about key dimensions of the circumstance under study.

COOPERATION

The structure of traditional project management even on simple projects reduces the ability and opportunity for people to work together by separating them into silos. Without cooperation across boundaries any project endeavor is bound to fail. The Last Planner® (LPS) developed by Ballard and the second author recognized this fact. In LPS supervision at the crew level plan their work with others to maximize performance across trades. In this, they support the objective of Lean Construction to optimize the project not the piece. Our interest in cooperation was provoked by a new perspective as postulated by Sam Bowles on the nature and evolution altruism, the sense of fairness. His explanation for what does and doesn't happen in IPD arrangements rests on the strong experimental and historical evidence. This perspective opens a new way to connect the social, commercial and physical aspects of Lean Construction by providing a new way to think about cooperation in projects, a new set of distinctions. He conclude that "*humans became a cooperative species because our distinctive livelihoods made cooperation within a group highly beneficial to its members and, exceptionally among animals, we developed the cognitive, linguistic and other capacities to structure our social interactions in ways that allowed altruistic cooperators to proliferate*." (Bowles and Gintis 2011)

It is obvious that the cooperation of various individuals and the trust between them is necessary to manage work in projects. Unfortunately, a construction claims industry has developed milking the industry of millions of dollars because project management failed to understand and employ the instinct for fairness between humans as proposed by Bowles and others. This has led to an industry that has alienated project participants. By contrast those working under collaborative Lean Construction protocols endeavor is develop this cooperative urge. Bowles and Gintis

in their concluding remarks in their book "The Evolution of a Cooperative Species" spoke about this phenomenon:

> "*Modern states and global markets have provided conditions for mutualistic cooperation among strangers on a massive scale. But altruistic cooperation remains an essential requirement of economic and social life. The reason is that neither private contract nor governmental fiat singly or in combination provides an adequate basis for the governance of modern societies. Social interactions in modern economies are typically at best quasi-contractual. Some aspects of what is being transacted are regulated by complete and readily enforceable contracts, while others are not. Transactions concerning credit, employment, information, and goods and services where quality is difficult to monitor provide examples of quasi-contractual exchanges. Where contracting is absent or incomplete, the logic of Adam Smith's invisible hand no longer holds. Decentralized markets fail to implement efficient allocations. But governments typically lack the information, and often the motivation, necessary to provide adequate governance where markets fail or are absent.*
>
> *Thus, social preferences such as a concern for the well-being of others and for fair procedures remain essential to sustaining society and enhancing the quality of life. In a world increasingly connected not just by trade in goods but also by the exchange of violence, information, viruses, and emissions, the importance of social preferences in underwriting human cooperation, even survival, may now be greater even than it was among that small group of foragers that began the exodus from Africa 55,000 years ago to spread this particular cooperative species to the far corners of the world."*

With this in mind, Lean Construction theory explains the inadequacies of traditional practice; we fail to capitalize on the altruistic and cooperative nature of human beings. Here we see the connection between Complexity, Cynefin and Collaboration and how they inform the one another. The Cynefin framework helps us make sense of the environment created by humans with their own prejudices. In order to make sense and take advantage of this phenomenon, theory building must be based on the foundations of human nature.

Owners want their facilities constructed and delivered hassle free within the agreed parameters. In order to achieve this they need the cooperation of various professionals who translate the owner's desires into a form communicable and understood by the contractors who physically construct theses facilities. Lean Construction provides an integrated approach where that cooperation is enhanced; there is no "them vs us" in the single purpose for which the team has been established. Success requires that team members benefit from the project as a team rather than as individual companies. Bowles demonstrates that there are social costs associated with a behavior that threatens the livelihood of others; the team punishes individuals who take advantage of the situation as Free Riders working for their own benefit at the expense of others. This source and power of this cooperative nature needs to be better understood in the context of contracts and informed by the Cynefin framework.

CONCLUSION

Lean Construction theory has developed in the last 20 years within a TFV model. Unless the future becomes suddenly predictable, it is hard to imagine a unified theory with universal applicability. This paper has explored a theoretical development maze and proposes that the theoretical base of Lean Construction can be enhanced considering complexity within the Cynefin framework and the cooperative nature of human beings as reported by Bowles. This agenda is at the frontier of research. It needs to be explored and refined.

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