

STRATEGIC APPLICATION OF LEAN THINKING

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ABSTRACT

As a result of a recent initiative by the UK Government, practitioners and researchers have been considering the development of lean thinking for construction from a strategic viewpoint. This has resulted in the recognition of a construction business system incorporating long term processes of partnering the supply chain, product development, production of components and project implementation. It is thought that by reorganising around these core business processes whilst adopting lean principles, it is possible to maximise the improvements in terms of quality of product and delivery mechanism.

The paper reviews lean construction literature and showing it to be both project focused and tactical in approach. It reports on a US study visit to see lean construction in action. The argument is made that whilst addressing a number of problems, there is a need for a more holistic approach in order to change successfully and develop the construction industry of the future. The benefits that product focus and long term continuity bring in terms of refocusing an industry to meet the challenges of the 21st century are discussed.

The construction business system and its constituent processes are described and the results of the interactive workshops that were used to test this approach are outlined. The result is a strategic framework, which is intended to guide practitioners when considering adopting lean thinking in construction. It recognises that practitioners must further develop the sub-processes.

KEY WORDS

Lean construction, strategy, lean principles, UK Construction Industry Task Force.

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BACKGROUND

During 1997, issues concerning the value that UK construction clients perceived construction companies were offering them came to a head with the setting up of a high level Construction Industry Task Force. This task force was to report to the Deputy Prime Minister about ways and means of improving construction. In essence this was concerned with building more for less capital expenditure. The latter a highly desired outcome when considered in terms of a new Government wanting to make an impact in health, education and social housing but with limited ability to generate new capital.

The Task Force members were drawn from client bodies who had previously seen their core businesses challenged and respond successfully. They now wanted to see a similar improvement in their construction work. Whilst being mindful of the needs of construction, they were not prepared to accept that construction could not achieve similar successes. They saw the sorts of change being suggested as challenging but not impossible.

The Task Force set about understanding what the leading edge of UK construction was currently achieving and how other industries had changed e.g. the off shore oil industry and the automobile industry. The concepts of lean production were identified as a key way forward. It was noted that whilst many tools and techniques were seen to be used, the end result from the client point of view was still not satisfactory. One area of notable success was that of partnering and the results were seen encouraging (Bennett and Jayes, 1998).

RESEARCH CHALLENGE

The challenge for the research team was to identify a coherent strategy for the construction industry to adopt in response to the challenges of lean thinking. These challenges would be in the form of targets to achieve on an annual basis and would include capital cost and time reductions, improved predictability, reduced defects and accidents and improved productivity and turnover and profits.

This paper describes the results of this inherently practical application of lean thinking. It is offered to the academic community in a spirit, which owes much to Seymour et al. (1997). Theory and practice must grow together and the work of the UK Task Force should be seen as a catalyst for the joint development of lean construction, both theory and practice, in the UK.

To identify a coherent strategy, the Task Force considered many types of evidence, both theoretical and practical. A review of existing academic work on lean production and case study reports of companies applying these principles were considered

LITERATURE REVIEW

The starting point for the academic review was the results of the International Motor Vehicle Programme (IMVP) research programme at MIT, which were reported in Womack et al. (1990). This text remains the most succinct description of the new production paradigm. Subsequent texts e.g. Kenney and Florida (1993) confirm the description of lean production but importantly make the link to the fact that the system was devised in practice and is heavily reliant on Japanese culture for success. It clearly points out that lean production is not a method that can be placed into any industry and expected to produce the exceptional benefits noted at Toyota. The point is made that the

production system is an end product of a bigger transformation process, which has its roots in culture, economics and historical forces. It depends upon people to develop it into a successful manufacturing paradigm for that organisation. The link is also made to the emerging post-modernist management theories which suggest that our knowledge will always be incomplete and that developing different perspectives and methodologies is a key to success (see Morgan (1993) and Banner and Gagne (1995)). In essence it stresses the importance of individuals becoming fully engaged and taking ownership of the organisational change process if it is to be successful. It should be noted however that this key element of lean production is often overlooked by observers who choose to adopt a more Taylorist view of lean production (Garrahan and Stewart 1992).

The first consideration of the ideas of lean production for use within construction is attributed to Koskela (1992). This seminal report considers the ideas expressed in the *Machine that changed the World* within a construction context. A new construction production philosophy is identified which has three distinct levels; tools and technologies, manufacturing methods and general management philosophy. He proposed the need to review construction production as a combination of conversion and flow processes when most frequently construction was simply seen as a number of disjointed conversion processes. This reflects the fragmented nature of the construction industry. What begins to emerge is the need to adopt a more holistic approach.

The subsequent lean construction literature falls into three broad categories of strategic, operational and tactical subjects with much of the research in the latter category. It deals with issues of production by focusing on tools and techniques that are based upon improving the how of site assembly. Alarcon (1997) shows that within the first three years of this work, implementation strategies, applications and tools are heavily reported. A small number of papers are recorded about concepts, which touch on issues of culture, translation (Brochner 1995, Melles 1994,) and people (Melles 1994, Fisher 1995). More recently ideas of theory development (Koskela 1997, Seymour 1996) have been put forward. A need for organisational change is hinted at and the importance of building self-learning teams but no clear picture emerges of what lean production might mean at a more strategic or organisational level. The researchers themselves recognise this (Koskela 1992 and 1993, Melles 1994, Brochner 1995).

Womack and Jones (1996) identified a similar gap in their own work of translating lean production into other industries and set out to define the underlying principles which lead to lean production. The results were published in 1996 and were intended as a guide to senior managers looking to “lean” their organisations. It was a strategic approach to achieving the lean production system described in the 1990 publication. In a sense it was the general management philosophy alluded to by Koskela.

For the Task Force research this was a key point. The strategy that Womack and Jones (1996) described was one of putting the customer first by offering value through the product that was required. What was needed was to consider how this strategy could be applied in construction and what an industry would need to do to achieve it. Conte 1997 recounts a case study of a commercial residential company in Brazil beginning to operate in this way. Barlow (1997) relates existing partnering work to the wider improvement scenario including lean construction. Reports such as Latham (1994) and Atkin and Flanagan (1995) identify aspects of change similar to those suggested by this approach. More recent publications (Gray 1996, Saed and Jones 1998) state the importance of adopting a process view and point to lean thinking as being appropriate. They do not

suggest a coherent, rigorous definition that could provide a starting point from which the industry could develop. The Task Force therefore needed to consider two questions. Firstly what evidence existed that this approach might be successful and secondly what would the industry have to do to achieve this new strategy.

LEAN CONSTRUCTION IN PRACTICE

A short study trip was undertaken to the United States in February 1998. The aim of the study was to investigate whether any US construction companies were adopting lean thinking principles and—if so—what results were being achieved and were there any perceived barriers in the approach. It was also intended to link up with the Lean Construction Institute (LCI), which had been formed by Glenn Ballard and Greg Howell, two leading academics in this field, together with a small number of companies.

With the help of the LCI, the opportunity arose to take part in an annual company conference led by The Neenan Company. They are Colorado States' 4th largest develop, design and build company and through the support of their owner David Neenan, have adopted a lean thinking philosophy. Four company case studies were completed as a result. In addition, the University of California at Berkeley and Stanford University were also visited. The key findings of the study visit are as follows:

- There is a small but actively growing community in the US of academics and practitioners looking to develop lean construction, primarily in connection with the Lean Construction Institute.
- The two leading companies are the Neenan Company in Colorado and Pacific Contracting in San Francisco.
- The results shown to date include:
 - ◆ Office construction times reduced by 25 % within 18 months.
 - ◆ Schematic design reduced from 11 weeks to 2 weeks.
 - ◆ Turnover increases of 15- 20 % (Pacific Contracting).
 - ◆ Productivity increases.
 - ◆ Satisfied clients looking to place repeat orders.
 - ◆ Project costs reduced.
- All companies have taken an experimental approach based upon an understanding of lean principles, the identification of an appropriate area to trial and first run studies to assess the potential. Full-scale trials are then implemented. Innovations include prefabrication, daily work monitoring, single piece flow on site, integrated engineering, procurement construction processes and 3D design.
- The learning culture and a single-minded desire to improve are very tangible and supported by senior management.
- All companies were partnering and a number of the suppliers were very keen to undertake lean work and were fully co-operating.

The study showed a number of different applications of lean principles, which were showing some interesting initial results. There was no direct evidence for adopting a strategic approach but discussions with the individual companies suggested that whilst the

learning opportunity afforded by their approaches was useful, there still remained a need to rethink the business strategy to support further development. The example of Doyle Wilson, the Texan housebuilder, used in Womack and Jones (1996) strengthened this idea since his whole approach to house building was developed around the concept of delivering value to the customer through a one stop shop for everything associated with purchasing a new home.

LEAN CONSTRUCTION STRATEGY

PRINCIPLES

Womack and Jones (1996) describe the business environment within which they saw lean techniques being successful. Five key principles emerge:

- Value
- Value stream
- Flow
- Pull
- Perfection

The tools and techniques such as kaizen, quality circles and just in time delivery are in essence the result of applying these principles to what is already being done i.e. at a tactical level. To achieve a lean enterprise they need to be considered at a strategic level. Consideration of these principles in this way for the UK construction industry is described below.

Value

The issue of value in construction has been much debated in academic circles. It is a complex one requiring several different value strategies to be combined within one project. The client may have one definition of value whilst end-users or stakeholders have others. By not being product focused, the industry gives itself a steep hill to climb at the start of each new project where the newly forming team have to spend time and energy eliciting the value definitions and trying to arrive at a consensus from which the project can progress. This difficult messy problem lies at the heart of the issues of value management (Green 1994).

In contrast by applying the principles of lean thinking several key differences become immediately apparent. Firstly by focusing on the customer's needs, construction has to adopt a product focus. Product focus enables a long-term dialogue to be started concerning the nature of value and how the product delivers it. More explicitly, the fact is that the client requires a building to suit his purpose and provide value for money. What the client is less concerned with is how the building is developed and how many people are involved in it. One rarely thinks about the suppliers to a production line when buying a car. More recently the concern has come from the clients simply because they are so dissatisfied with what they are offered and are forced to become involved in the construction process to minimise their own risk. The vision that this product and customer focus suggests is not new. Aspects of it have been alluded to in many previous reports

(Atkin and Potheary 1994, Bennett et al. 1988, 1989,1996, Gray 1996) but the ideas have not been developed by the industry.

Value Stream

The value stream identifies all those steps required to make a product. The key technique behind the value stream is that of process mapping. However, it is process mapping for a very specific reason; that of understanding how value is built in to the building product from the point of view of the client. At a strategic level it offers a perspective on defining what is to be done. By taking this top down approach, the idea of identifying value streams such as the structure and the building envelope and considering how these systems will be designed, supplied and constructed, offers a different way of organising for construction. It gives purpose to the concept of technology clusters, which Gray (1996) postulated.

At a more tactical level the value stream mapping can be used to identify where waste lies in a particular process and how it can be achieved more effectively. There is extensive literature on using process analysis in this way as part of lean construction (Alarcon 1997). An important difference between construction and manufacturing is that in manufacturing the production processes exist per se and can be walked on the floor. In the traditional construction process these operating processes are defined as they are needed and until construction teams have more continuity within one product field they cannot be recognised as generic processes.

Flow

Strategically flow is concerned with achieving a holistic route through the means by which a product is developed. It attacks the fragmentation that is inherent in our industry today by revealing it to be highly wasteful. Many have recognised this wastefulness (Latham 1994) and the leading solution is seen to be partnering. As Bennett (1998) points out, the early stages of partnering are a necessary pre-requisite for improving construction but without the concept of flow production applied at a strategic level. Partnering remains only a partial solution. Organising to achieve seamless flow delivery of a product gives purpose to a partnering relationship. It suggests that the design, supply construct processes for a value stream delivering a key system e.g. the building envelope should be organised on a flow basis, the key to which is achieving the finished system on site at the right time.

Pull

At a strategic level, pull really identifies the need to be able to deliver the product to the customer as soon as he needs it. The traditional construction process pushes the client into an often protracted development process where risk and uncertainty are prevalent. The principle of flow suggests a vision where the ability to define quickly what the client needs from a building in relation to his business and subsequently customising a well understood product to best fit those needs means that buildings can be delivered more predictably when the client requires them.

Perfection

This is a key concept at the strategic level because what it defines is the need for this way of working and organising to deliver construction products to become a way of life with an inherent culture. To achieve perfection means constantly considering what is being done and how it is being done and harnessing the expertise and knowledge of all those involved in the processes to improve and change it.

VISION

The conventional construction process is ineffective in developing products, choosing the key components for the project, co-ordinating the engineering design and managing the supply chain. This leads to an inefficient and time consuming process of design co-ordination once key contracts have been let and a poor engineering fit on site.

The conventional construction process assumes that clients benefit from choosing new consultants, contractors and suppliers on a competitive basis for every project they do. Consequently there are no arrangements within the structure for learning, innovation or the development of skilled people needed to deliver quality and efficiency in the process.

The starting point for the lean construction process is the premise that permanent alliances will form who jointly take responsibility for providing, to a series of clients, a particular brand of products. Over time, these products become increasingly customer focused, more cost effective and have an ability to be delivered very quickly. This develops a culture, which can define value because it understands both the customer and the product in great detail. This leads to a redefinition of what it is that the industry does through the application of the lean thinking principles at a strategic level. Furthermore it continues to improve by looking to achieve perfection. This it can do through continuous improvement because it has both a stability of workload and permanence amongst the team members, which allow development work to be successful.

LEAN CONSTRUCTION BUSINESS SYSTEM

The work this alliance does can be recognised in the four key processes, similar to those of Toyota (Womack et al. 1990); partnering the supply chain, product development, project implementation and production of components. The main premise of the lean construction process is that the same team of suppliers, contractors and consultants work on a series of projects, continually developing the product, applying quality improvement and waste reduction techniques, and incorporating arrangements for learning and continuous improvement. Many large and expert client organisations are increasingly doing this through partnering agreements. These agreements can be developed further and the same benefits could be provided to occasional clients by developing integrated teams that offer defined products.

The challenge that faces the industry is to understand more fully what it means both financially and operationally to adopt this strategy. The key processes outlined above have been thought through in more detail and tested in a number of workshops with practitioners. A summary for each process is given below. It is important to understand that they exist within the permanent alliance and that they differ from the understanding one might assign to the terminology today.

PARTNERING THE SUPPLY CHAIN

This process is the mechanism by which the alliance is managed and by which it provides value to its customers. It has a strategic responsibility for identifying markets and making decisions about the product(s) the alliance offers. It identifies potential projects. It forms and maintains the supply chain for providing the product to the customer through rationalising the number of suppliers, although at least two alternative sources for each component or skill are retained. Suppliers are given continuity of work through long term agreements over the life of a generic product. Key suppliers become full members of the team and are involved in product development and project implementation from an early stage. They are also made responsible for managing their second tier suppliers.

The relationships within the supply chain are carefully monitored through measurement and feedback on issues such as quality, cost, and delivery. Suppliers who are not able to meet these targets are supported in their change programmes. The alliance has responsibility for developing the individuals within the supply chain, the processes by which the product is delivered and the technology that is required to do so. In essence it provides the glue to bind the traditionally fragmented process together around the customer and the product.

A key sub-process within partnering the supply chain is that of sharing the gain. As the alliance becomes more skilful in reducing costs, the benefits must be shared across the team as a whole. The mechanism for doing this has to be identified and tested and updated as necessary.

PRODUCT DEVELOPMENT

The team responsible for product development is a permanent team made up of architects, consultants and key suppliers. The definition of product development is:

"Defining the attributes of an operating facility that will deliver sustained satisfaction to customers."

The aim is to develop a generic model of the product to an appropriate level. For some alliances this may mean establishing the customer requirements and translating them into key construction components and features. For other alliances it may be to develop a number of design models one of which will be selected depending upon the particular project site and the business requirements for the project.

The key sub-processes are:

- *Defining value* – this needs to be done from the customer's point of view through tools such as value management, quality function deployment, simulation and end user surveys. This will define attributes. Attributes are characteristics that deliver customer satisfaction.
- *Defining performance requirements* – the attributes need to be converted into a comprehensive set of generic performance requirements for the product. These give substance to the product concept.
- *Product innovation* – this team is continually working to find innovative ways to improve the ability of the product concept to deliver customer satisfaction. It may be through technical developments or greater understanding of customer needs. Feedback loops on performance are essential and it is the

responsibility of this team to gather appropriate data and to use it to enhance product performance. Any innovation is thoroughly considered and tested before it is incorporated into the product. It is important to note that within this construction business system this work is done outside of the project process although it has close links with it in terms of understanding buildability of design etc.

- *Modeling of standard designs* – if desired, any standard designs can be modelled and components identified for bulk purchasing.
- *Target costing* – if product development is carried through to model development it becomes possible to develop the target cost for the model based upon known material quantities, man-hours and plant requirements. The price can then be determined for the product, which gives the alliance a suitable profit margin based upon what the market will currently stand.

A critical point for product development, which each alliance needs to consider, is the nature of the output from the process. This identifies exactly what it is that is passed to the project implementation team when a suitable project has been identified. Equally the mechanisms for feedback loops also need to be in place to ensure that the information is of the right type and quality to allow the product team the best opportunity to further develop the product design.

PROJECT IMPLEMENTATION

The project implementation process flows seamlessly from product development. It is a stream of projects taking the output from product development, implementing it in reality for an identified client and feeding back to product development performance achievements, problems and areas for improvement.

The start point for project implementation depends upon the finish point of product development. In essence there will always be a *project definition* processes where the client, the site and the business case are identified. The next step is to *customise the product* to the particular client and identify how the product will be delivered in this instance.

Through *pre-planning*, long-standing teams will develop generic processes for designing, supplying and constructing the product on the basis of the value stream maps described previously. This leads to the ideas of the project being organised as a series of teams around key physical systems. An important role is that of the project integrator who seeks to manage the interfaces between the systems and has responsibility for the overall integrity of the product.

The ability to *prototype* the product becomes an important tool in terms of checking the interfaces and structural integrity. As a result of the alliance environment and the long term nature of product development, the use of 3D libraries of components and model building protocols becomes much simpler than using 3D technology in a bespoke environment. The objective is to rehearse both the engineering fit of the components and the process of construction. This removes much uncertainty from the site assembly process and allows closer integration of the construction teams. The lean principles of flow and pull can be considered and work carried out to facilitate their achievement.

When prototyping is complete, the process of *site assembly* can begin. It is at this production level that many of the techniques such as kaizen, last planner, calibre and

quality circles can be used to both manage the production more effectively and to solve any problems that will inevitably arise because of the nature of construction.

PRODUCTION OF COMPONENTS

The component manufacturing processes are in principle no different from the processes that the best manufacturers use today. In the lean construction process, component manufacturing and logistics are much more closely integrated with site construction and significant improvements can be made in design for construction, on or off site. Furthermore the detailed engineering and preplanning inherent in the lean construction process enable the construction process to flow and pull the dependent processes of manufacture and design. Parts are produced to customer order, picked up by the construction team and delivered just in time to site, reducing stockpiles, theft loss and damage. Suppliers work with alliance members to achieve a seamless process and the performance of suppliers is measured and they are supported in their improvement work by the alliance.

CONCLUSION

In setting out to achieve its objectives, the Construction Industry Task Force has investigated the applicability of the principles of lean thinking to construction at a strategic level. It concluded that whilst the principles of lean thinking have been applied at a tactical level in terms of improving how work is currently done, little thought had been given to changing what it is we set out to achieve in the first place. By applying the principles of lean thinking at a strategic level it becomes clear that to deliver customer value means reorganising around a product. This product focus gives continuity and stability, both of which facilitate further tactical work in the drive for improvement.

However, the lean construction approach described above has a number of risks. Firstly, there is no guarantee in the open market that adopting a product focus will be viable. A first thought is that this would favor companies who can begin to change a particular aspect of their company whilst maintaining their profitability in other areas. The anecdotal evidence, however, suggests that smaller companies with senior management who actively support the culture of doing business in this way are more likely to be successful because of the high level of commitment and belief in the underpinning culture.

There are a number of examples where alliances have formed for different reasons around a product and these are perhaps the most likely to be able to move forward and develop the key processes defined above. Companies formed to deliver Private Finance Initiative projects are an example.

Viability in the market place depends upon two factors. Firstly the ability to develop a good steady supply of work so that the teams can move forward from project to project developing their learning and ploughing their experience back into improving both the product and the delivery process. Secondly to maintain steady teams within the alliances. This allows investment and innovation to create new processes and technologies to meet new challenges.

In outlining its hope for the UK construction industry of the future, the Task Force has been careful not to be prescriptive. It wants to encourage the industry to consider its ability to deliver value to customers from the customer's point of view, not the traditional risk averse route. It recognises that the hard work is still to do. From these ideas,

practitioners must first embrace the principles themselves and subsequently seek to develop them within their own cultural environments. The Task Force intend to encourage this work by supporting a number of projects where there is a clear determination to test out various aspects of the processes described above. For this a long-term viewpoint is required. It is hoped that as these processes develop, the use of existing lean techniques will be incorporated at the tactical level and that by using them in the bigger framework they may show greater benefits. These benefits will be measured against the targets set out in the Task Force work, which will allow the changes in efficiency and effectiveness to be measured.

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