AN EXPLORATION OF KNOWLEDGE AND UNDERSTANDING - THE EIGHTH FLOW

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ABSTRACT

The argument for understanding Lean construction as a socio-technical field is growing and the need to better consider the role of human beings within construction systems is becoming the dominant factor in project success. Many current attributes of lean already focus on people and on human engagement approaches but the field of lean construction addresses project environments that are often complex and highly variable. The authors argue that the successful delivery of these projects relies on the creation of a common understanding of the project objectives within the diverse value systems of project participants and wider society. Additionally, many of the new ways of working that lean thinking brings already support the creation of a common understanding and could be harnessed to better effect.

Based on a literature review and supported by case study examples the authors explore the nature of knowledge and understanding and position them within an eight flow model for construction production. The findings indicate a need to reconsider the development of a common understand for each project due to the tacit nature of experiential knowledge held within the project team and the specificity and complexity of the project environment. As a result effort is required to generate and maintain a common understanding throughout the project duration. The continued attention and action required to maintain this common understanding elevates it to a flow of equal status to those identified in Koskela's flow production model thus increasing the number of flows to eight. A significant lean construction case study is revisited and examined to identify interventions undertaken to achieve this generation and management of common understanding thus demonstrating that this development already exists, albeit intuitively, as an element of "lean thinking".

KEYWORDS

Lean construction, flow, complexity, systems, understanding, value, theory, knowledge

INTRODUCTION

There is considerable evidence contained within the IGLC body of knowledge (www.iglc.net) that a number of hypothesised strands are maturing into tried and tested theories that are particular to the application of Toyota's lean product design

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(TPD) and production system (TPS) within the construction sector. These maturing theories have a common application within the design and construction of buildings and infrastructure around the world, leading to a new way of working. It is also becoming clear that only Toyota can be Toyota and that organisations across the myriad business sectors must contextualise and adapt the approaches identified as "Lean" to suit specific environments and not attempt to simply copy the observed TPS tools and techniques. This contextualisation and adaptation requires the actors not only to understand the specific environment before implementation but also to understand the underlying lean philosophy and the changes it imposes on human perceptions and practices. Based on a literature review, the authors explore the nature of knowledge and understanding and position it within the complexity of project delivery. The authors present knowledge as a resource of equal importance to Koskela's seven resources (Koskela 2000) and propose that understanding knowledge is a flow of construction project production. This hypothesis is presented as a model. The second hypothesis that this understanding needs to be common is discussed using both literature and case study evidence. Finally practical examples taken from case study evidence show how common understanding can be developed and managed within a lean construction system.

WHAT IS KNOWLEDGE?

In his critique of prevailing economic theory, Hayek (1945) eloquently explains that the basic assumption that resources can be allocated as a process of logic is flawed because it ignores the fact that knowledge is distributed and resides with any number of individuals. He extends this point to cover planning (of economic activity) providing for us some explanation of the success of the Last Planner™ System (LPS). The collaborative element of the LPS clearly collects this distributed knowledge together to plan and deliver the economic activities of construction. The idea that collaborating is a good way to distribute knowledge has been growing in practice since the 1980's with the recognition of the benefits of location clustering (Porter 2008). Emphasis on learning and sharing knowledge has been developing and with it the realisation that these two things are difficult to achieve in current competitive environments as organisations seem to deliberately blur explicit knowledge to preserve a perceived competitive advantage (Simonin 1999). Simonin (1999) cites numerous papers that confirm how challenging the sharing of knowledge is for organisations and individuals. It seems much research has been undertaken to better understand the components of knowledge itself and the ambiguity surrounding how it is caused or comes into existence. It is certainly more than information alone. Using knowledge continues to be problematic, in their research on knowledge protection, ambiguity and relational capital Lee et al (2007) discuss the difficulty of owning knowledge, identifying it as becoming economically more important than *"access to raw materials and cheap labor"* (Lee et al 2007 pp58). Protection of knowledge through ambiguity they speculate will become increasingly common to preserve competitive advantage as firms seek to disconnect knowledge from the logic of inputs and outputs (Lee et al 2007). This, they say causes a paradox for organisations, acting against the need to share and internalise knowledge from other organisations to improve performance. However, Simonin's original research on knowledge ambiguity relates it to the (lack of) understanding of the links to cause and effect, input and output within specific environments and identifies three elements of non-transferable knowledge: tacitness, complexity and specificity (Simonin 1999). This is good news for the construction sector as the project environment is uniquely defined by three similar properties that should continue to protect knowledge within organisations when they move from one project environment to another. Using Simonin's view, it becomes obvious that within a construction project environment the sharing of knowledge should not affect the competitive advantage of the organisations involved due to the tacit nature of the skills required, unique complexity and specificity of the project outcome. The challenge to knowledge sharing that remains therefore is ambiguity caused by lack of understanding across the project (design and) delivery team. This has been recognised within the lean literature as the need to develop a common understanding underpinning integrated project delivery or IPD (AIA 2007, Mossman et al 2011) across all project actors. The intention being that early integration of parties enables a sharing of knowledge fostering a rapid growth in the understanding of project requirements. This approach recognises that each supply chain actor brings tacit knowledge of not only technical issues but also of previous project experiences that may not only not be relevant to the new project but may even be actually harmful – the expectation of contractual claims for example. Echoes of Shingo's model of process and operations (Shingo 1989) can be heard in the IPD approach as it represents the overall construction process alongside the individual operations. Bertelsen et al (2007) combine Shingo's model with the metaphysical ideas of Koskela and Kagioglou (2005) to explain process (or flow) as time based as opposed to activities which exist in the present and are more "thing" based. Bertelsen et al (2007) go on to use Koskela's seven flows (Koskela 2000) to model the construction process as a complex network of flows leading to activities (operations). They conclude that management of the activities/operations alone is not enough to deliver the process effectively – the network of flows must also be managed. Connecting this idea of a network of flows to Hayek's contention that planning economic activity (operations) must consider the distribution of knowledge amongst individuals (Hayek 1945) delivers the first proposition: that if knowledge is distributed then its use must be connected to the network of flows.

WHAT IS COMMON UNDERSTANDING?

It is possible to apply the Transfer, Flow, Value lean production model (Koskela 2000) to the use of knowledge. By this we mean knowledge can be considered as a resource to be drawn upon and transformed to deliver benefit. This interpretation brings the second proposition: that a common understanding is the result of the transformation of knowledge in order to define and deliver project value. Project value can only be achieved if the flow of common understanding is managed throughout the design and construction operations. The transformation of knowledge into understanding has been modelled by Chui et al (2006) who indicate three dimensions to sharing knowledge. These can be related to construction as follows:

- Structural – equates to the information flows (one of Koskela's seven)
- Relational – includes the ability to trust
- Cognitive – the degree of shared language and vision

These three dimensions dictate both the quantity and the quality of the common understanding of knowledge and are in turn are influenced by the expectations of both the individuals and the combined project community. It can be seen therefore that knowledge and understanding are not the same – knowledge is the basic resource and understanding is the output of the transformation of knowledge. Because knowledge is flowing across the project its transformation is not a static activity but must be related to the overall project delivery process. This can be seen within the Toyota systems (TPD & TPS) through the development, integration and engagement of human endeavour in problem solving and continuous improvement across the whole supply chain (Rother 2010). The transformation of knowledge in project delivery exists in two forms, the transformation and flow of knowledge itself and the input of knowledge and its transformed state of understanding into the operations as illustrated in Figure 1 below.

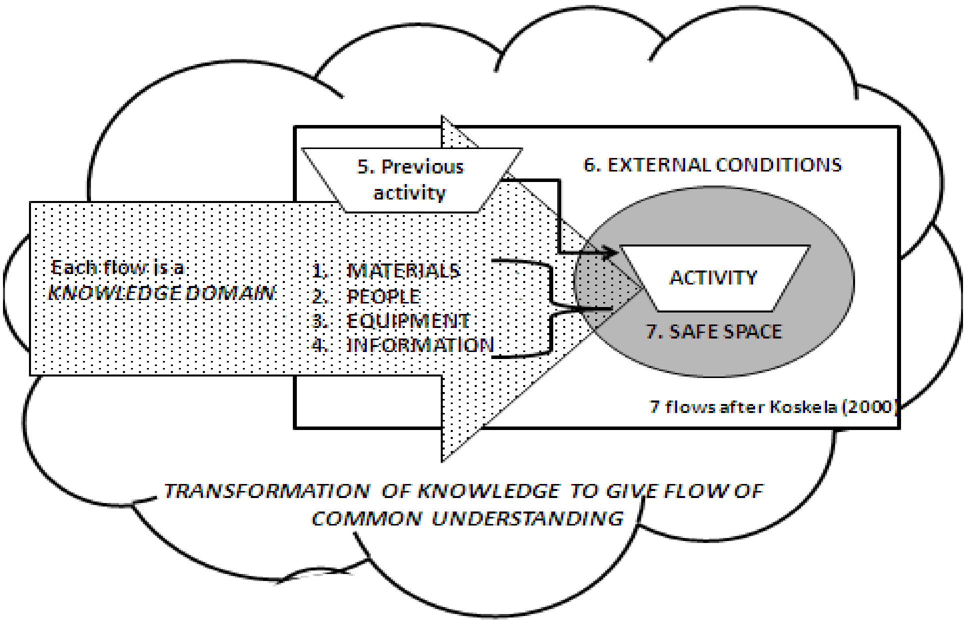

Figure 1. Duality of the Flow of Common Understanding in Project Delivery

Common understanding is a clear function of the next customer principle embedded in the make ready portion of LPS. Boldt Construction has expanded this aspect to include transparency of specific methods in the development of their eDocuments. These were observed during a site visit to their Sacramento Hospital project, July 2012. These documents contain the construction experience of the operatives about particular activities and are prepared not to "steal" the knowledge but to assist with the planning and execution of interconnected activities. Smoother regulatory and quality control process turned out to be an additional benefit to the use of these documents not initially considered. In this example a common understanding is facilitated by removal of the ambiguity of knowledge resulting from its tacitness, specificity and complexity described by Simonin (1999). Because of the unique combination of specificity, complexity and tacitness of knowledge required for each construction project, the production of these documents on one project are not seen as a threat to competitive advantage on other projects by the organisations and individuals involved in this example. This means a common understanding exists only for the project it has been developed for it is not directly transferrable to other projects. Some developed understanding can be converted into processes such as the use of eDocuments, any developed understanding is taken away to become tacit, experiential knowledge to be drawn upon in future projects if applicable. The understanding converted into new processes is still likely to require the development of new common understanding on future projects. This will be the case even if the project team is identical because of the specificity and complexity of the new project environment, but the effort to reach this consensus will be reduced. In this way, Deming's improvement spiral is enacted (Deming 1986)

COMMON UNDERSTANDING IN LEAN CONSTRUCTION

The idea of a common understanding runs through the heart of the TPS governing how people do their jobs, interact with each other, identify problems and ensure the product and services flow. In their definition of the DNA of TPS, Spear and Bowen (1999) talk of a highly defined and rigid system that provides great adaptability and responsiveness to change. Toyota it seems has taken great care to remove ambiguity from their operations – an aspect that Boldt Construction for example, is beginning to experiment with. The construction project environment is very different to the factory environment and consolidated, stable supply chain of Toyota and is hugely variable and unstable. As a result much of the lean implementation activity in the construction sector is focused on reducing variability and improving flow on a project by project basis and is now looking more towards the Toyota Production System for inspiration for better design processes. As a result, many of the lean approaches implemented in construction have within them techniques to foster understanding (Pasquire 2012). But the question remains – what is to be understood?

Lean project production combines three perspectives of production (Koskela 2000):

- (T)ransformation – the alteration of resources or means from one state to another nearer the customer's requirements through defined operations. May also be called the work or what is to be done.
- (F)low – smoothing and levelling throughput by removing interference or constraints across the system using defined processes. May also be called efficiency or how it is to be done.
- (V)alue – a more intangible element with far reaching economic, social and environmental consequences beyond the commissioning construction client (Pasquire and Salvatierra-Garrido 2011). May also be called the ends or why it is to be done.

The need to understand what, how and why has been described by Ballard (2008) in his update on Lean Project Delivery (LPD) but it is not clear whether all participants need to have exactly the same understanding about the what, how and why or whether even one, say the project leader, must have or even can have a complete understanding. The relational and integrated arrangements of LPD and IPD suggests that no-one person does have "the full picture" but that this picture becomes apparent when the appropriate parties come together – rather like the multi-screen displays seen at major events, each screen delivering only part of the complete picture. These appropriate parties need to keep coming together for the duration of the project to enable this big picture to be visualised and realised hence the collaborative nature of lean construction supported by a clear commitment cycle (Macomber et al 2005) to aid implementation. The challenge therefore is to maintain the big picture through the collective effort of the individuals who must all share a common understanding that they have a particular position within that specific bigger picture and critical interdependency with others. This is the systemic view that lean thinking brings to projects – requiring optimisation of the whole system and not the traditional way of optimising individual parts of the system. This sub-optimisation of parts is embedded in traditional procurement where work packages (in both design and construction) are procured and managed individually. This in turn promotes individual objectives rather than collective project goals and is one of the most difficult practices to overturn. This is situation directly correlates to a lack of the relational and cognitive elements required for a shared understanding of knowledge identified in Chui et al (2006). In addition to the common understanding of the project the new methods of working that lean brings with it need to be deployed across all participants. This provides an extra dimension to the understanding needed. It can be seen therefore that a substantial effort is needed in order to maintain a common understanding of both the project delivery (what, why and how) and the new methods of working. A lean construction research case study is revisited to identify what management methods were implemented to ensure the development and maintenance of a common understanding.

MANAGING THE EIGHTH FLOW: A CASE STUDY

Crown House Technologies is a tier one mechanical, electrical and public health (MEP) contractor and a leading prefabricator of modular building services for the construction sector in the UK. The development of the Crown House Technologies Lean Construction System has been widely reported through both the IGLC and other

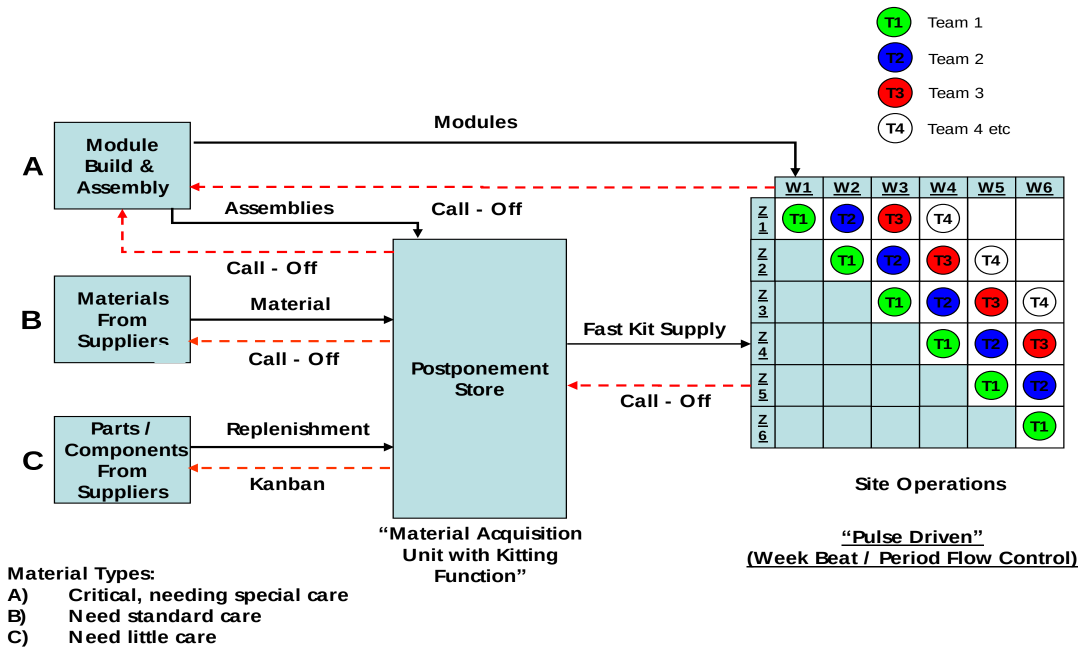

Figure 2: CHt Construction System

journal publications (Court et al 2009 (a),(b), 2008, 2007, 2006, 2005). The focus of these papers was the research undertaken to develop the system and results from its implementation in the construction of the North Staffordshire Hospital in the UK. The system is presented in Figure 2 above.

This case study has been revisited to investigate the activities undertaken to ensure a common understanding and manage it as the eighth flow. The original research was action based and the researcher the project leader for Crown House and able to detail this additional research from participant observation. The activities comprised of specific training events to disseminate company strategy and the new thinking along with workshops aimed at the development of specific working initiatives arising from the new common understanding as follows:

Using health and safety legislation to drive changes – all workers already accept the need to change practices because of H&S. This was done through a series of 30 minute workshops attended by all project participants on the following issues:

- Ergonomics – making the work fit the worker and workplace organisation. This aspect addresses occupational health issues such as musculoskeletal stress, safety hazards caused by untidiness, the waste of unnecessary movement, the waste of unnecessary travel, the waste of time lost looking for things, fetching things or waiting for things.

Figure 3. Common non-ergonomic practices

- Lean construction - giving team members insight into lean by explaining the company strategy to be lean and agile, what this means and how the Construction System delivers this.

Operational design - working groups were held with tradesmen to design work cells based on what the workers specified as their requirements to do the work. This addressed issues identified using ergonomic principles and required the workers to think through how they were going to work in advance, improving their productivity through new equipment, tools etc. see Figure 4 below.

Although the new methods were developed with the workers, effort was needed to ensure the new way of working prevailed. In the early stages workers often forgot that their kit was mobile and continued to walk to and from their perceived supply base rather than take it to the place they were working.

Figure 4. New thinking in operational design developed with the workforce

Planning workshops – these were continuing events throughout the project duration and took several forms:

- With the design team, to explain how the synchronised week beat flows back through to design stage. The design team needed to work to the pulse schedule to enable the synchronisation of the entire project value chain.
- With other trade contractors to secure buy in from them prior to appointment. It was important that the trade contractors became partners to the system or its success was jeopardised. Activities included the MEP project leader (author) and project planning and production control manager sitting in with the procurement team on sub-contractor tender interviews to ensure alignment.
- Weekly Last Planner workshops for design, procurement, and offsite manufacture, site assembly, commissioning. They collected the project team together to implement the construction system by understanding each other's requirements, look-ahead, make ready, constraint analysis and the promise cycle.

General activities – there were a number of activities that helped to generate a common understanding about the operation of the system and the new methods of working that were to be employed. These included:

- Setting up ground rules and guiding principles. These were formed through a collaborative effort amongst the team member to agree how the system was to be implemented, issues that were important, issues that would be difficult, issues that would require continuing attention etc. The ground rules and guiding principles helped the team remain focused and consistent through the implementation effort.
- One to one sessions with key stakeholders. There were times during the project when some redirection and adjustments were needed.
- Lean wall game was devised to help differentiate good from bad practice. This used photographs of varying site practices participants were asked to rank these practices on a scale from excellent through poor to enable workers to visualise what the new working practices looked like and were intending to achieve. This was an important implementation of visual management that was found to be effective in the development of a common understanding.

DISCUSSION AND CONCLUSION

The case study demonstrates a continuing and comprehensive effort to ensure that project participants understood the project requirements and the new ways of working imposed by the system. These efforts took place without the knowledge of the need to explicitly manage the flow of common understanding and the activities were designed intuitively as a management in collaboration with the participants. This collaboration ensured the collection of the distributed knowledge and the exposure of the whole team to the collected thinking generated a significant step towards a common understanding. The generation of the common understanding in turn delivered a significant step towards the elimination of waste in the design and delivery of the project through the implementation of Just In Time logistics combined with workplace organisation and ergonomic, mobile work cells which increased the productive time of the workers in a safe way. Because the workers (from designers to operatives) shared a common understanding of the project's lean strategy they were able to adapt the way they worked to the new systematic and highly structured approach which extended upstream to the work undertaken in design.

It can be concluded that the competitive advantage perceived as a barrier to sharing knowledge should not be a barrier in most construction projects due to the high level of uniqueness in the tacitness, specificity and complexity of each project – the more complex the project the greater the level of uniqueness and the lower this barrier. The example of Toyota shows us that this can also be the case in repetitive, manufacturing contexts. The development of a common understanding relies not only on the quality of the information and documentation (structural elements) available but also on the ability to relate and share cognitive elements. Both of these are major components in lean construction and explicitly form building blocks within IPD and LPD. It can be seen therefore that not only is common understanding a vital flow within lean construction it is already embedded as a critical element. For this reason it must be elevated to a managed flow with the seven other resource flows of construction physics. The evidence from the case study supports this conclusion by demonstrating the efforts taken to develop a common understanding in the case study to implement a lean construction system.

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