DEVELOPING LEAN THINKING IN CONSTRUCTION: A NATURALISTIC ENQUIRY

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ABSTRACT

The purpose of this paper is to describe a research methodology and interim findings concerning the investigation, through ethnographic case-based research, of the impact within a construction project of the partial implementation of a value stream approach. It is intended that by undertaking research of this nature, a contribution can be made to the understanding of the cultural aspects of both lean construction and associated construction process theory.

The research was undertaken within the wider context of the Movement for Innovation in the UK and in particular as one of a number of demonstration project trialling the ideas expressed by the Construction Industry Task Force in 1998 (DETR 1998). It traces the development of a model for identifying and implementing the value stream approach during project implementation, mapping planned construction processes and subsequently comparing planned with actual for the purposes of developing a target baseline for continuous process improvement.

Through a pilot study to test the model, a qualitative analysis methodology is used and some propositions put forward relating to culture, the value stream framework and process mapping. It is intended to develop these through a major ethnographic case study.

KEY WORDS

Value stream, process mapping, culture, social constructivism, qualitative analysis

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INTRODUCTION

This paper describes action research that is now in its final stages. It builds upon the work done in the UK by the Construction Industry Task Force (DETR 1998). It was reported at IGLC-6 (Garnett et al. 1998). The recent work is outlined here for the purpose of illustrating how concepts of lean construction are being developed in the UK through the collaboration of the construction industry, major clients and the UK Government. In academic terms, there is a further purpose, which is to open to a wider academic audience for debate, the methodology used within the research and some of the initial findings of the work.

The paper follows a classic structure with the objectives of the research first being set in the wider context of the current change initiative being led by the Movement for Innovation. The research methodology and in particular its epistemological basis is outlined. This is a key element of the work because it builds upon some initial discussion already prevalent in the construction management field concerning the relative benefits of both positivist and constructivist research (Seymour 1996). The reasons for choosing a constructivist approach are defined from the literature review of Lean Construction and Process theory.

The first part of the research is the theoretical development of a model by which the concept of value streams could be applied within the construction environment. The second part of the research is based upon action research and involves testing the model with two project teams. A similar research concept to that used by Cherns and Bryant (1984) was adopted. The model was used in a pilot study with a construction project team. The active aim was to reduce cost to construct the pilot study office block by reducing man-hours through process analysis. In addition, qualitative analysis of the resulting data led to the generation of a number of propositions relating to three areas of interest arising from the literature work:

- Effectiveness of social constructivism based models in developing lean construction methodologies.
- Usefulness of the value stream approach to organise projects.
- Use of specifically created processes as a mechanism for managing construction projects.

The second iteration of the action research was concerned with implementing the revised model to a greater extent to introduce the concepts of value stream work in a repeat product environment and to evaluate its benefits. The academic rigour of the research was increased by gathering empirical data from this second study in the manner of an ethnographic case study. This was subsequently analysed to gather evidence to support or refute the propositions generated through the pilot study. A contribution to theory might thus be made.

At the time of writing, the ethnographic case study is almost complete and some initial analysis has begun. Findings from this work are reported here and some theoretical conclusions are drawn. The aim of the research is to investigate, through an ethnographic case study, the impact within a construction project of the partial implementation of a value stream approach. The intention is not to justify the model through the benefits that accrue to

the project in terms of cost and time reductions but to understand the cultural implications about operating in a team based, integrative, participative way.

BACKGROUND THEORY

The two key elements of the research, the use of value streams within construction and the investigation of how process work might change the way construction projects are managed, emerged from a review of the lean construction literature the key points of which are summarised below.

Firstly, though much of the early work is production focused (Womack et al. 1990, 1996, Koskela 1992), some thought is given to the wider context of the organisation within which production takes place and the inherent culture. Kenney and Florida (1993) conclude that whilst the lean production paradigm has much to offer, the success of its implementation depends upon the organisational environment and culture within which it is developed. An epistemological review of the Lean Construction literature focusing on the conference papers of the International Lean Construction Group from 1993 to 1997 revealed that only two papers adopted an epistemological basis other than positivist.

O'Brien (1995) describes his research into construction supply chains using an exploratory case study approach, which he attributes to Yin (1989). Seymour (1994) deliberately sets out to bring methodological considerations to bear on assessing quality control systems. His particular dilemma was that his research "*was carried out within what may be called the conventional construction management research paradigm, which, as I will argue, comes firmly within the rationalist tradition"*. He recognised that the failure of quality systems was generally due to the culture of the industry and suggests that the interpretive view has much to offer lean construction research. It can therefore be argued that the development of lean construction might benefit from more constructivist-based research.

Secondly, building from the research completed in the UK in 1998 and reported in Garnett et al. (1998), it is contended that, enterprises will need to structure suitable operating frameworks, based upon the underlying principles of lean, but applied at an operational level. DETR (1998) suggests four processes that are a good starting point and align with those of Womack et al. (1990) in their original description. The processes are partnering the supply chain, product development, project implementation and production of components. These processes have however not been operationalised either in theory or practice. This is a critical problem for lean construction. The research therefore set out to develop an operational framework for delivery of construction projects based upon the value stream approach.

To use value streams appropriately relies on the use of process mapping to identify and remove waste and of "managing construction through processes". A review of process theory and particularly, process theory in construction shows that the current thinking in construction is again predominantly towards a positivist view where generic processes are sought by which best practice can be established (Kagioglu et al. 1998). There is little evidence of much construction process work based upon the established principles of, for example, soft systems methodology (Checkland 1987) A trial of this less Tayloristic approach was made by Green and Simister (1999) in their evaluation of mapping client's business processes as part of the briefing process. In contrast, lean thinking recognises that people are a key factor for improving processes and the way they view their work is

important. It is therefore contended that if process mapping is used, as part of value stream work, it should be based upon a constructivist methodology of participation and integration. It should also be developed by the project team itself as part of the project delivery process.

The findings of the literature review can therefore be defined as three hypotheses:

- Successful development of lean construction requires strategies and methodologies, which are based upon social constructivism.
- At project level, an operational framework derived from the application of lean principles is a key element of success.
- At project level, processes of design, supply and construct must be created for each project.

MODEL DEVELOPMENT

META MODEL

A model for organising construction projects was developed centred upon the use of value streams and process mapping to identify and remove waste. It was developed as part of an action research project with BAA plc where the objective was to reduce the cost of construction through application of lean thinking principles. A strategic process was developed for the project based upon an existing generic project process applied to all BAA projects. It is shown at Figure 1.

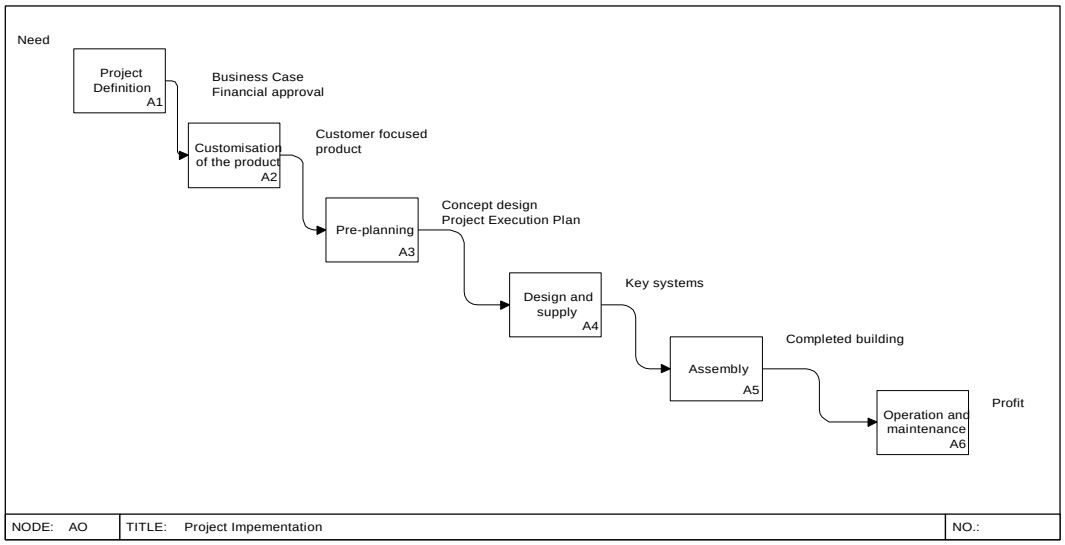

Figure 1: Project Process

The value stream work seemed to support the planning process within this context. This arose from the logic that in manufacturing, the first step in value stream work is to map the way raw products are brought together to form the finished product. In construction, however, this value stream has to be created since, especially for bespoke products, it does not yet exist in a form which can be readily studied.

The building can then be viewed as a series of value streams, which converge to form the finished building. Along this value stream there are three key processes which add value, design, supply, and construct. This train of thought gives rise to the meta-model at Figure 2.

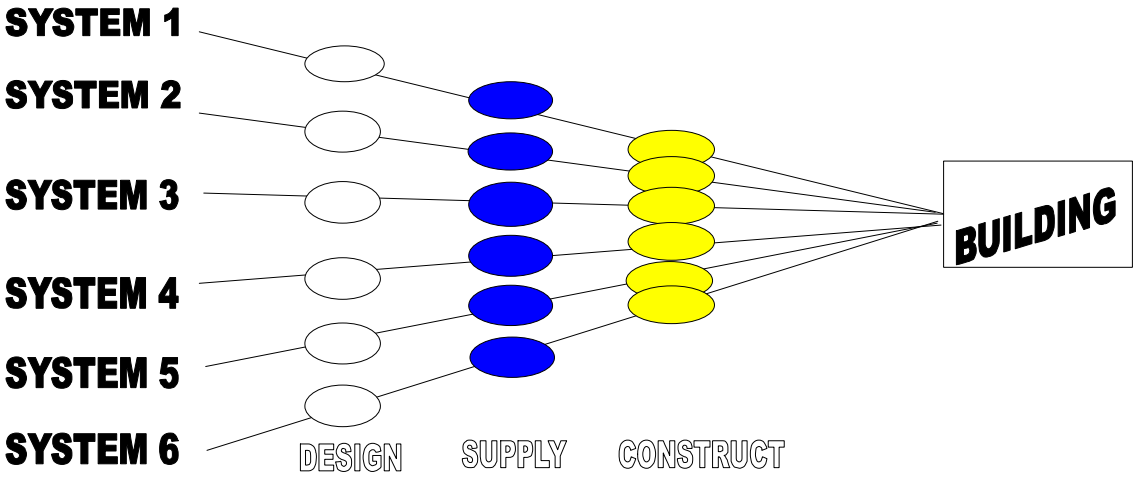

Figure 2: Meta-Model Representing Value Adding Processes within Value Streams of a Building Product

The key systems would be identified as parts of the building, for example, the frame or sub-structure and the project team should be organised to deliver these integrated parts of the building as a discrete entity. Note in Rethinking Construction (DETR 1998) this view would not necessarily operate within the project team but would radically the alter the way the UK industry was structured as these integrated delivery teams would be companies or alliances in their own right.

The second part of the model that was developed concentrated on a methodology, based upon constructivist principles. The processes of design supply and construct for a project could not be established except by the project team themselves so that consensus was gained about the way in which the work would be completed. A series of workshops would be used to carry out team process mapping work where the designers, construction managers and key suppliers would come together for a particular system on a particular project and map the way the delivery of that system would take place. The objective was to identify any waste that could be removed eg duplication of work between suppliers. The aim was to identify an optimum sequence of work and all necessary interfaces for completing the process. The team could also set targets in terms of time and eventually cost for the delivery of the system. It was intended that, by planning work in this way, a lean effective delivery plan could be developed.

RESEARCH METHODOLOGY

The research methodology was chosen to be commensurate with the underlying epistemology of the model ie-social constructivism. It has two parts. The first was an initial pilot study using part of the model within an existing project team. The research strategy was

that of action research with the project team. Three types of results were developed: the process results for the project team, development of the model as a result of feedback and lastly qualitative analysis of the work to identify a theoretical framework that might support or refute the original propositions made from the literature work. The use of propositions in this way to develop theory is commensurate with inductive research and the basic premises of action research, which is to induce theory from practical work. Cherns and Bryant (1984) use the development of propositions in this way.

Subsequently a fuller test of the model was devised as part of the industry wide initiative in response to "Rethinking Construction" (DETR 1998). The research strategy was similar in that the work was carried out as an action research project but the empirical data was collected in accordance with the principles of naturalistic enquiry ie a case study. The aim was not only to investigate the use of the model but also to contribute to theory through examining the softer issues arising out of the implementation process especially any perceived barriers to implementation. The case study would be analysed in a similar way to the pilot study with particular attention being paid to the qualitative analysis. More evidence is sought to refute or support the three propositions arising out of the literature review.

PILOT STUDY

BACKGROUND

The pilot study took place in 1997 over a period of six months. The objective was to support a project team, who was challenged with reducing the cost of construction for an office block on the perimeter of Heathrow Airport, from £85/ft2 to £75/ft2. The mechanism for cost reduction was to be the application of lean production techniques within the concept design specifically to target the delivery process for the building. Some of the cost reduction would additionally come from value engineering of the product itself.

The previously described model was developed during the early stages of the project and trialled during the early stages of concept design. The specific methodology was to map, for one key system (the pre-cast frame), the construct process only. This was a limited test of the model but included teaching the pre-cast frame team about lean production and process mapping. A workshop scenario was developed with the objective of mapping with the frame delivery team the way in which construction on site would take place. The intended objective was to identify the processes and put man-hours and plant costs to them. Analysis of this planned construct process would take place by the team and the results are considered at a subsequent target setting workshop. The resulting process map would form the blueprint for undertaking the construction work on site against which the actual process as it occurred could be compared.

In the event only the initial workshop took place and whilst it was favourably received at the time, it was not further developed.

Three types of data were obtained:

- Process maps created during the workshop
- Feedback on the methodology, i.e., the workshop material.
- Qualitative data as shown in Table 1

Table 1: Table of Pilot Study Qualitative Data

Notes of meetings
Background information to the project itself.
Diary which recorded all interactions with the project team
Notes made during the model definition phase.
Preparation material for the workshop.
Material collected at the workshop eg Rich pictures, flow charts etc, post workshop evaluation questionnaires.
Consultancy report
Writings and comments made during an earlier draft thesis stage.

ANALYSIS

Initial analysis was of the hard data in terms of the individual processes. This was less than satisfactory since it became clear during the workshop that the contractual basis on which the project team operated prevented some of the suppliers from releasing specific man-hours data. However, action reports were fed back to the project team about the way in which the pre-cast frame should be constructed.

The qualitative analysis of the data was more successful with a number of propositions being generated through a manual qualitative analysis process, the methodology for which is as follows (Robson 1993):

- All data from the interaction with the project team was stored, filed and a document summary produced.
- The data was trawled to identify key issues and comments and these were recorded on the data record sheet together with a reference and an appropriate code.
- For each code a series of postcards was used to collect all the relevant pieces of data. Key topics were identified and each piece of data recorded to the appropriate topic. For each topic key words were identified and propositions generated.
- The propositions were collected together and related to three previously key ideas generated from the wider doctoral research work. Discussions were held with a number of colleagues to refine these propositions ready for use within the case study qualitative analysis.

QUALITATIVE RESULTS

The propositions resulting from the analysis are shown in Table 2. These findings were also used to develop the model before its second use within the ethnographic case study. The main differences included:

- More rigorous selection process for the value streams
- Extending the methodology to include a series of workshops as the project developed in order to get to the required level of detail as personnel joined the project team.

- Concept of using the comparison of the planned against actual process maps to develop a baseline target process and time schedule for future projects.

From a theoretical point of view, the propositions generated from the pilot study will form the framework for the qualitative analysis of the major case study.

Table 2: Table of Propositions after Pilot Study

Culture
The participative approach is supportive of construction process mapping and was reported as beneficial by the project team.
The technical ability of individuals is key to successful process mapping of construct processes.
The relationship between the construction manager and individual suppliers is very significant in this environment
A measurement strategy will be more successful is the team participate in setting and beating its own targets.
Operational Framework
Operationalising the meta-model with a specific project team is critical for success of this approach.
Value stream delivery teams are the key driver, not the processes of design, supply and construct.
The choice of the value streams greatly affects the likelihood of success.
Lean principles assume a causal relationship between process cost and waste which is not inherent in traditional UK construction contractual scenarios.
Process data is not readily available from suppliers.
For repeat products, process data is best derived from an actual project.
Success is only achieved when the work of a value stream delivery team is consistently viewed and managed as processes.
Rates of change within projects are affected by external constraints.
Process Mapping
Site specific issues need to be explicit at the time of the process mapping workshops.
There is a relationship between process work and critical path planning of a construction project.
Those doing the process mapping work should be the same as those involved in implementing the planned processes on site.
Single point responsibility, for delivery of a process on site, is key.
Interdisciplinary working is important in process mapping work.
Process mapping work builds project teams and aids project communication.

CASE STUDY

BACKGROUND

The case study is a 26,000 ft^2 Tesco supermarket being constructed at Haslemere in Surrey. The design process was already under way when the research work began. The model was used with the design team to plan how the construction work could be delivered as a series of value streams. Process mapping workshops took place to identify a "planned" construct process for each value stream.

The researcher remained with the project team on site during construction and monitored with the suppliers the "actual" processes as they occurred. Part of this monitoring included the use of activity based planning, a lean construction tool, to achieve flow and to help record process information.

Post process interviews were held with each supplier to review the results and to gain further learning. It is intended to hold review meetings with the value streams teams to

understand how the work should be better planned in future. Part of the action research results will be a consultancy report for the client recommending how further lean principles could be implemented and identifying from the data gained at Haslemere, a baseline process map with target times for continuous improvement.

ANALYSIS

Although the consultancy reports are key parts of the empirical data, the academic analysis will concentrate upon the qualitative analysis of the data to understand the implications for the project team of undertaking work in this way. The following data types have been collected: (1) Working notes, (2) Weekly construction logs, (3) Intervention diary, (4) Written reports. These will be analysed using content analysis with a coding system based upon the findings from the pilot study. The aim is to build further the arguments for or against the original propositions and to relate the findings to ongoing research in related fields.

CONTRIBUTION TO NEW THEORY

It is expected that the research will contribute to new theory in three different ways. Firstly, a discussion relating to social constructivism and how it might contribute to lean construction theory. This furthers a discussion already underway in construction management journals where the dominant research epistemology is positivist. Secondly a consideration of how useful the concept of value streams might be in construction and a better understanding of the social and cultural implications of adopting this approach. Thirdly a contribution to process theory questioning the benefits of adopting a social constructivist approach to process work and also developing appropriate methodologies for supporting process work in construction. Finally, by using the action research approach it is hoped that the principles of lean thinking will have become more widely disseminated and that the industry might be persuaded that radical change through action research is a useful way forward.

CONCLUSION

This paper has set out the research methodology and interim findings of a piece of action research whose objectives were two-fold. Firstly the dissemination into construction practice of the ideas of lean thinking at an operational level and in particular the ideas of value streams and the associated process mapping work. The second objective is to contribute to the theoretical field of lean construction through ethnographic case-based research.

It is acknowledged that the findings portrayed here are in reality to support the description of the constructivist nature of the research methodology rather than to generate debate about the applicability of value streams and associated process work. These more detailed findings will be the subject of subsequent papers on completion of the research.

An evaluation of the completed research so far suggests that, whilst a number of US companies have achieved significant gains by adopting the ethos of lean thinking, the current UK construction industry is finding it a difficult cultural challenge. It has a predilection for "quick-fix" tools which the research work so far has shown to have only limited potential. An example is the way in which the notion of carrying out process mapping work is accepted but

the cultural change implications, concerning contractual arrangement and costing structure to relate waste, man-hours and cost, are treated with great suspicion. There is also a strong desire from the industry for identifiable tangible (preferably cost based) benefits of process mapping to be demonstrated ahead of implementation. Whilst this can be seen as acceptable, if conservative, business practice, it conveys a lack of desire to invest intellectually in the ideas of lean thinking to the extent that cultural change becomes a necessity. If the UK construction industry is to develop towards the vision that was expressed last summer by the Construction Industry Task Force, it must surely do this. It is hoped that by focusing this research on both the development of lean construction at an operational level and by reporting on and drawing conclusions from the ethnographic approach, the cultural aspects of adopting lean principles may be elicited. This may lead to a better understanding of successful implementation strategies.

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