Integrating Design and Construction From a ‘Lean Perspective’

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ABSTRACT

Better integration of project processes has often been identified as the key issue regarding construction performance improvement. In some countries lean construction has become well established, although there appears to be considerable diversity in the interpretation of the concept. Lean construction initially focused on production aspects, but gradually design issues have started to receive more attention and integrating construction design and production processes from a lean perspective are beginning to be addressed. A summary of three ethnographic cases, taken from a recently completed PhD, help to highlight a number of pertinent issues facing practitioners and researchers. The aim was to identify some of the practical challenges underlying the implementation of approaches promoted as ‘lean’ and compare this with published research/theory. Findings from the USA and Denmark help to emphasise the importance of a number of interdependent factors for achieving better integration, namely: value identification/specification; an appropriate project delivery framework; structuring and planning of delivery processes; transparency; management and leadership; learning; and the importance of local context.

Keywords: Design/Construction Integration, Lean, Local Context, Project Processes, Value.
1. INTRODUCTION

‘Integration’ has in different ways been high on the agenda of the current construction debate. A typical characteristic of construction is the separation (and fragmentation) between design and production, which in general is considered to be problematic (Bouchlaghem et al. 2004; Baiden et al. 2006) and publications have often argued that design and construction should, in one way or another, become better integrated (e.g., Brandon & Powell 1984; Hughes 1989; Bröchner 1990; Koskela 2000; Anumba et al. 2000; Austin et al. 2001; Gray & Hughes 2001; Emmitt 2002; Bouchlaghem et al. 2004; Kimmance et al. 2004). Although integration and other change initiatives for improving construction performance have been on the agenda for a long time, and though the industry frequently adopts new terminology, it has been argued that very little has changed structurally (Cox & Ireland 2002).

In Denmark and several countries ‘lean construction’ has been another major theme of recent years’ construction debate. Hitherto ‘lean’ application in construction design, most commonly referred to as ‘lean design’, has received much less attention than production-orientated initiatives but has gradually become more prominent in publications and, so it appears, in practical initiatives in the industry.

1.1 About the research

In 2003 a three-year doctoral research project set out to investigate processes and methods for integrating construction design and production from a perspective of the ‘lean’ philosophy (See Jørgensen 2006 for full details). The research, which was conducted through a combination of literature studies and three ethnographic case studies from Denmark and USA, set out to answer two research questions (RQs):

RQ1: Is the lean philosophy appropriate as a means for pursuing integration of construction design and production processes?

RQ2: Which processes and/or methods and/or issues are crucial or critical for integrating construction design and production from a perspective of the lean philosophy?

Regarding RQ1 it was concluded that as a means for pursuing integration of design and construction processes the lean philosophy can be appropriate - though not on its own - provided that the notion of ‘end customer’ is redefined to represent a range of construction stakeholders including wider society, and provided that value is defined with reference to the whole-life perspective in which a built artefact delivers its value and generates waste. Ambiguity, vagueness and uncertainty over value aspects define the limit to which the lean philosophy can be applied in an integrative construction project system’s perspective. From the perspective of practical application, wider contextual issues, including structural, social
and cultural aspects, also contribute to considerable limitations regarding the extent to which lean philosophy can be applied as a means for design/production process integration. Due to the limitations of the conference format this paper will focus on the findings from the three case studies that were instrumental in answering RQ2. Before continuing to the case findings it is necessary with a brief introduction to the two main issues of this paper: ‘lean’ in building design and construction, and design/construction integration.

2. ‘LEAN’ IN BUILDING DESIGN AND CONSTRUCTION

Since the 1990s ‘lean’ application to the built environment has become an increasingly prominent theme in the construction management debate, not least in terms of industry attention. A development strongly influenced by the broader production and management debate where lean has been a leading management fashion for soon two decades. ‘Lean construction’ has been embraced in the construction improvement debate and promoted as a ‘new understanding of the construction process’ that could or would bring substantial improvements of performance and stakeholder satisfaction. The international attention increased with the publication of the Egan report Rethinking Construction (DETR 1998). Though a discussion paper more than a contribution of research this publication promoted “Lean Thinking in construction” as an approach that should be adopted for bringing sustaining performance improvement for the UK construction industry. The substantial argument was the claim that the lean thinking approach had delivered large improvements in manufacturing, in particular the motor vehicle industry, and where already applied in construction.

There is considerable confusion regarding what is meant by ‘lean’, ‘lean construction’ and ‘lean design’. In construction the debate emerged from discussions of the scope for applying of ‘the new management philosophy’ to construction, which was first taken up by Koskela (1992). A thorough literature review highlighted that the ‘lean’ debate is based on many competing definitions and interpretations. Most commonly definitions are implicit (fully or partly), vague, interpretative and/or based on references that eventually lead back to dominant popular management literature, most commonly Womack et al. (1990) and Womack & Jones (1996), which does not provide a sufficiently clear and coherent definition of the ‘lean’ concept. Thus it is not surprising that there is great diversity in the interpretation of what is meant by ‘lean’ in building design and construction. Comparison of examples from Denmark and California has illustrated that the management innovation ‘lean construction’ appears to develop local meaning through processes of diffusion, interpretation, adaptation and adoption in accordance with mechanisms explained through previous research regarding diffusion of innovations (Jørgensen et al. 2005).

The lack of a common definition for ‘lean construction’ and ‘leanness’, has been discussed by Green & May (2005) who found that lean
construction and lean production are “variously understood as a set of techniques, a discourse, a ‘socio-technical paradigm’ or even a cultural commodity.” Based on an empirical study from the UK construction industry and interviews with authors of the Egan Report, Green & May suggest that three models represent the practical adoption of lean in construction: a lean model of ‘waste elimination’, ‘partnering’, and ‘structuring the context’.

An important outcome of this research is that the findings indicate that lean construction, while highly diverse in interpretation and applied practice, is inspired by lean production rather than just a transferred copy of it (a relationship between lean production and lean construction previously proposed by Koskela et al. (2002)). It is concluded that the meaning of lean construction is continuously renegotiated within localised contexts (Green & May 2005). Clearly there has been a (still ongoing) development in debate, understanding and practice within the field of lean construction, which appears to follow a pattern of some similarity to that of the development of debate on lean production (Jørgensen 2006).

2.1 Lean design

In relation to construction, ‘lean design’ is considerably less discussed and investigated than production issues. While also lacking a universal definition, ‘lean design’ in construction is used as referring to approaches, principles and methods for managing processes of design and/or of product development. Publications on design management in relation to lean construction generally adopt the term lean design or, emphasising that they are specifically addressing the management aspects, with the term lean design management. The lack of explicit or clear definitions of what is meant by ‘lean design’ is no less noticeable than the missing clarity regarding the conception of ‘lean construction’. Many publications have discussed design in relation to lean construction, but it is in the most cases not clear when and if authors discuss ‘lean design’, ‘lean design management’ or e.g. ‘design for lean construction’ and it is not always clear if such terms are used to describe different phenomena (Jørgensen 2006).

2.1.1 Working definition

The literature on the lean philosophy, lean construction and lean design did not suggest that two (principally) different definitions for lean design and lean construction would be appropriate for the research. With a focus on enhancing (customer) value and eliminating/reducing waste from a system’s perspective, it can be argued that the lean philosophy and its basic elements address both design and production processes. However, the practical implications of applying a lean approach are naturally very different in the case of construction design than when compared to construction production/assembly. On the basis of findings and considerations discussed above, the research adopted the following working definition of ‘lean design’ and ‘lean construction’:
Lean design and lean construction:
I. Applies a systems' perspective to enhance value and eliminate/reduce waste and drivers of waste in the construction project;
II. Adopts customer (client/user/stakeholder) preference as the reference for determining what is to be considered value;
III. Approaches design and construction management through a focus on processes and flows of processes;
IV. Adopts an understanding of design and construction/production activities from a perspective of three simultaneous conceptualisations: 1) transformation; 2) flow; and 3) value-generation;
V. Manages design and construction/production processes with a (customer) demand-pull approach as far as this is applicable.

3. DESIGN/CONSTRUCTION INTEGRATION

Design/construction integration is a very large and broad theme that has been explored from a variety of perspectives and approaches. If considering the lean philosophy's focus on value optimisation and waste minimisation, the 'lean role model' of the Toyota Production System and the applied measures of addressing waste through systematically pursuing resource efficient flows of information, materials and transformations, it can be argued that four different integration approaches of the larger construction management debate would, each in their own way, be obvious choices:

- Aspects of vertical and/or horizontal integration in the construction supply chain and in between construction delivery and the management of real estate facilities and related services.
- Integration of information systems for product and processes (often approached through a strong IT orientation).
- Integration of working practices and collaborative processes in the construction project organisation.
- Constructability (often dealt with from the perspective of specific practical advices for producing designs with a high level of constructability, e.g. the 'design for assembly' approach).

Many perspectives on integration would arguably have been of high relevance to the research but due to the limitations working practices and collaborative processes (third bullet point) provided the main perspective adopted for this work. However, as illustrated by the three case studies, practical pursuit of design/construction integration is influenced by a large number of contextual factors, which is why it is not possible to completely ignore other perspectives. Baiden et al. (2006) have suggested that integration can be considered as “the merging of different disciplines or organisations with different goals, needs and cultures into a cohesive and
mutually supporting unit”, and that integration in construction describes the introduction of “working practices, methods and behaviours that create a culture of efficient and effective collaboration by individuals and organisations”. Baiden et al. use the term ‘integrated construction project team’ to characterise “a highly effective and efficient collaborative team responsible for the design and construction of a project.” Integration here refers to the team bringing together “various skills and knowledge, and removes the traditional barriers between those with responsibility for design and construction in a way that improves the effective and efficient delivery of the project”. The authors thus approach the theme of design/construction integration and team integration from the perspective of achieving integrative project processes and working practices. A feature shared by lean design/construction, which was decisive for the choice of adopting definitions and categorisations proposed by Baiden et al. as reference points for the research.

3.1 Design/construction integration in a lean perspective

Principally, the lean philosophy promotes an integrated approach to designing and making, and some lean construction proponents have proposed that ‘production’ should be understood as consisting of both designing and making (e.g.: Koskela 2000; Ballard & Zabelle 2000; Ballard 2002) but, all in all, a review of publications on lean construction suggests that terms are used in a large variety of ways and different notions of ‘design’ and ‘production’ appear to co-exist. For clarity, this paper will apply the ‘traditional’ terminology and use the term ‘production’ for the processes concerned with the physical making of what is previously specified through design. While it is important to be aware of differences in the terminology used, the need exists for specifying on a more concrete level what is understood by a lean approach to design/construction integration. Integration of lean design and lean construction will be understood from the perspective of achieving a design/construction project team that works integrally in pursuit of a lean approach to project delivery.

4. CASE STUDIES

A multiple case strategy was adopted for exploring the practical application of lean approaches to design/construction integration. Data collection comprised ethnographic methods, with data collected from a variety of sources. The methods chosen were:

- Non-participant observations of design meetings (and when possible other project meetings) of the projects studied;
- Analysis of project material (tendering and bidding documents, meeting minutes, correspondence etc.) accessible;
- Qualitative interviews with project participants (an element of the case study strategy which was later revised, see below).
Three large projects (a residential and a rehab-housing project in Denmark and a health care project in California) were studied in the period 2003-2005. All three projects were, although in different ways, highly complex and represented three different approaches and strategies to procurement and to design/construction integration through ‘lean’ application. While the Californian project was managed by the client under a design-assist setup the Danish case projects were organised under two different design-build structures, one of which with a substantial element of partnering and initiatives for early involvement of suppliers. For further details, see (Jørgensen 2006).

4.1 Findings

The research highlighted that it is possible to identify a number of aspects that (in theory as well as in practice) influence and, to various extents, limit the applicability of the lean philosophy to construction; both on the more general level and also in relation to providing an appropriate means for design/construction integration. Although it was not possible, on the basis of the research, to propose a general model describing their collective influence, the case studies revealed some issues that appeared to be influential in relation to integrating design/construction processes with reference to a lean perspective:

- Project value specification;
- Active client, user and stakeholder involvement;
- Decision and decision process transparency;
- Transparency regarding value/waste consequences of design decisions;
- Management of design iteration processes;
- Collaborative design with contractor/supplier involvement;
- Commitment from project participants (including suppliers);
- Project team learning.

From the three case studies the eight themes listed above were found to encompass the aspects of most central importance. Many of these aspects are reflected in several of the eight themes that are in many respects overlapping and are summarised below.

4.1.1 Project value specification

The case studies clearly illustrated the importance of thoroughly specified client and stakeholder value(s) if efforts to systematically enhance value and eliminate waste are to be possible in a broader perspective encompassing both design and construction. Case findings suggested that specification of value must be made explicit, and if representing a compromise between different stakeholder interests the value specified
must be sufficiently viable/supported to ensure the stability of decisions necessary for effective planning. Observations revealed that it was not always sufficient for the construction professionals to be informed about a client/user preference. Understanding of the circumstances or assumptions behind a preference/wish/demand was often essential.

The value specification process is likely to take significant time and effort, and it is necessary that the project delivery team, in addition to knowing what has been specified as value, understands the underlying factors and preconditions of individual stakeholder value, needs, interests etc. The project management and delivery team must understand the ‘political arena’ of the different stakeholder interests and the power/influence backing them.

4.1.2 Active client, user and stakeholder involvement

As generally recognised in construction management literature, effective involvement of clients and stakeholders is a critical factor to successful project completion (Brandon & Powell 1984; Lawson 1997; Emmitt 1999; Emmitt & Gorse 2003). Case projects illustrated that the role and active involvement of stakeholders is of central importance to practical efforts of applying a lean perspective to integrating design and construction. Often information or response from client/stakeholders was a critical factor for progressing with project decisions of importance for integration. All three case studies showed that this information was not always easy for designers to get.

Of particular importance from a lean perspective is that late project changes easily result in significant waste and may compromise value delivery when comparing to what could have been achieved had the needs/wishes prompting the change been known or anticipated at earlier stages. Active client involvement and meticulous briefing process is necessary for limiting the risks of such changes.

4.1.3 Decision and decision process transparency

This theme is a key issue in several respects, not least when pursuing an integrated approach to design and construction project phases. Information generated in ‘upstream’ project processes is decisive to the specification, planning and execution of downstream activities, and there is significant interdependence between subsystems where a decision regarding one system influence design and assembly processes of other systems.

Establishing transparency regarding decisions, decision processes and their wider consequences (e.g. in terms of impacting the liberty of choice regarding decisions in later project stages) is a critical factor when pursuing an integrative approach to systematic value optimisation and waste reduction. It is of high importance to ensure that transparency is achieved also from the perspective of client, users and other stakeholders directly involved. Case projects emphasised the importance of structuring the project for achieving an appropriate match between decision/approval
processes and design processes. A particular challenge, it seemed, was to ensure that decisions and decision progress would appear sufficiently transparent to client, users and other stakeholders, especially those that were not construction professionals. This commonly created difficulties when previously fixed decisions were subsequently challenged by some of the project parties.

4.1.4 Transparency regarding value/waste consequences of design decisions

This theme is closely connected to the previous regarding decision and decision process transparency. To systematically address value/waste aspects in the project system it is necessary to establish transparency regarding the wider consequences of design decisions. Two case findings stand out as being central issues. First, that efficient contractor/supplier feedback requires a high level of detail in the preliminary design. This does not necessarily imply that effective feedback cannot be achieved before late design stages when basic parameters are fixed, but that considerable parts of the design will need to be worked through early in the process when it is still possible to use feedback for altering design concepts without compromising design intent (Jørgensen 2005; 2006). Second, that contractor/supplier knowledge and engagement contributed to both the improvement of client/customer/stakeholder value delivery and to the addressing of waste aspects related to later project stages. For the case projects a specific challenge was achieving efficient cost feedback at early stages of the design process. One of the conclusions of a case project where a ‘design to target cost’ methodology was applied, was that efficient cost feedback required a great level of detail in the design, which demanded increased work intensification in early design phases.

4.1.5 Management of design iteration processes

From the value/waste understanding of the lean philosophy, design iteration will generate a lot of waste through drafting, rework, examining possibilities never pursued etc. The question is not simply about minimising resources spent on design but (in principle) to manage design to deliver best possible value through project processes generating less possible waste over the system’s perspective. An important issue of lean design management is thus to enhance positive iteration while avoiding negative iteration (i.e. work that does not contribute to solutions and that could have been avoided). The case findings suggested that the two most fundamental aspects of managing design iteration is to enable positive design iteration on value delivery and to ensure that crucial parameters are not fixed too early to preclude positive improvements. Yet it is necessary to make sure that parameters and specifications are fixed sufficiently early for the design and project progress to be efficiently managed. This is a considerable challenge for design managers, since achieving the correct balance will
influence design quality and the financial viability of the project from the perspective of the design office (see Emmitt 2007 for further information).

4.1.6 Collaborative design with contractor/supplier involvement

Collaborative working is a very wide theme, which involves a large number of issues. The mere sharing of information, which appears to commonly be mistaken for 'collaborative design', is but one of them. In addition to various aspects of coordination, collaborative design often has implications, such as the need for project participants to change their usual ways of working in order to enable effective interaction with other parties. Changes may be perceived by project participants as significant and hence difficult to handle, and can have wider social and organisational implications (which are outside the scope of this paper). Achieving the sufficiently high degree of effective collaboration necessary to address value/waste issues in the wider project perspective requires considerable effort from project participants to actively participate in a large number of project processes - some regarding aspects of which individual participants’ area of responsibility may be only marginally and indirectly affected. The case studies showed that effective collaborative design was challenged by difficulties of ensuring sufficient supplier feedback, and that this often required a high level of design detail in early project phases. Facilitation and leadership appeared to be crucial issues, not least for achieving effective communication between the construction professionals and other stakeholders, for example building users.

4.1.7 Commitment from project participants (including suppliers)

For addressing value and waste in a wider perspective and for avoiding sub- or point optimisation, commitment from the whole supply chain is a necessity, especially in an organisationally and technically complex design/production system such as construction.

The case projects showed that a lack of engagement from individual organisations/project participants was a significant impediment to the application of lean strategies. It was strongly indicated that the issue of commitment is of central importance to the wider theme of design/construction integration. We would argue that this must be present from the very beginning of projects and that design and project managers must constantly stimulate the system to maintain a high degree of commitment.

4.1.8 Project team learning

Continuous improvement, systematic experimentation and continuous learning on all organisational and technical levels are important aspects of the lean philosophy. The importance of learning processes for successful project performance in construction (like other industries) has long been recognised and it has been argued that already at pre-project stages
learning processes are influential in shaping project circumstances (Whelton 2004). The opportunity to discuss value via a lean-based project delivery strategy helped to stimulate exchanges of information/knowledge and thus enabled learning to take place.

5. CONCLUSIONS

The findings of the research can be summarised under a few processes/methods that were found to be of crucial importance for integrating design and construction from a perspective of the lean philosophy:

- **Value identification, specification and communication:**
  - Achieving a common understanding of customer value, needs etc. and securing that they have the support necessary for project continuity.
- **Establishing an appropriate project delivery framework:**
  - Establishing incentives, agreements, resources (incl. time, financial means, and human and organisational resources), contracts etc. supporting design/construction integration and an overall lean approach.
- **Project organisation and the structuring and planning of delivery processes:**
  - Composition of delivery team and its organisation, and project scheduling, planning and preparation processes.
- **Establishing transparency:**
  - Of organisation, decision-making, technical issues, and of value/waste consequences.
- **Management and leadership:**
  - Management of project and project related processes, including active involvement of project stakeholders.
- **Learning:**
  - Supporting and stimulating learning, team learning and exchange of knowledge at all levels of project processes and at all relevant levels of the organisations involved.

5.1 Implications

One outcome of the research was that it highlighted the importance of project participants possessing a thorough understanding of the specific project context. Findings suggested that this must be present at all levels of design and planning activities when pursuing integrated approaches to value enhancement and waste elimination. This appeared to be as important as the procurement approach adopted. By their very nature, construction project always address and impact upon local needs, something 'international' project teams need to be particularly sensitive to.
The research indicated that knowledge of the specified project, client, user and stakeholder value (and values) is likely to be insufficient for effective collaborative design and planning. Deeper understanding of underlying contextual circumstances defining value and values will be necessary for ensuring efficient identification of suitable project decisions. This may add considerable complexity to (international) project collaboration where individual project participants work in geographical, social and cultural contexts that are some distance (both physically and metaphorically) from the context of the environment being developed through construction.

6. REFERENCES


