Lean design management: exploring perception and practice

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Abstract:
Many construction projects suffer from delays and cost uncertainty with the result that, in many cases, the customer or client is not satisfied with the final product. The importance of managing the early design phases effectively and efficiently is well-established, although how best to do this is not so clear. The successful use of lean management in the construction stage (using the principles largely developed by Toyota) has opened up the possibility of using lean management in the early design stage, thus helping to establish a systematic approach to managing construction projects and the organisations that participate in them. This study, explores the interpretation and application of lean design management in architecture, engineering and construction (AEC). A survey questionnaire was used to obtain a deep understanding of the issues connected with the current processes and practices in design management. The findings from 125 survey responses provide evidence that inefficiencies in design management practices in the UK construction industry are related to ineffective design management processes (e.g. briefing, design planning, etc.) as well as problems with procurement. The main conclusion drawn is that lean design management appears valid for implementation in the construction industry but needs to be customised according to the project context to achieve the desired value.

Keywords:
lean design management; client briefing; design process waste; design process value stream; architecture, engineering and construction (AEC).

1. INTRODUCTION

Many construction projects suffer from delays and uncertainty in terms of cost with the result that, in many cases, the customer or client is not satisfied with the final product. Research has highlighted the importance of the early design phases in helping to reduce such uncertainty and improve quality; thus, the importance of managing this stage effectively and efficiently has been made clear. Despite this, much research effort has been, and continues to be, expended on the construction phases, with initiatives such as lean construction trying to deal with challenges that many would argue should have been dealt with in the earlier design phases. Clearly there is a need for better design management and attention is turning towards this phase in order to address these deficiencies. The successful use of lean management in the construction stage (using the principles largely developed by Toyota) has opened up the possibility of using lean management in the early design stage, thus helping to establish a systematic approach to managing construction projects and business. Indeed, it could be argued that a lean culture must be embedded within an organisation before it can apply the principles to projects.
However, a clear definition of what is meant by lean design is still being debated (Brookfield et al., 2004; Jørgensen & Emmitt, 2009).

The focus of this research was to obtain an understanding of the issues connected with current processes and practices in design management, as well as interfaces between lean management principles and the design process. This aims to help in deciding whether or not lean design management can be implemented in design processes for construction projects. If so, at which of design stages organization can start applying lean thinking management without interruption. This investigation is carried out within the construction industry in the UK using a survey questionnaire.

2. LEAN DESIGN MANAGEMENT

Management deficiencies have been shown to have a negative impact on the efficiency of the construction process in terms of the waste generated and contract variations occurring during construction while the success of a project and the value realised are highly dependent on the decisions made during the very earliest stages of a project’s development (Emmitt et al., 2004; Thyssen et al., 2008). Poor control of the early (design) stages has been identified as a major factor in reducing the overall performance and efficiency of construction projects (Hansen and Vanegas, 2003). An overall project’s final outcome depends on firm control in the earliest phases in order to avoid the effect of mistakes and omissions. This control involves design briefs, avoiding poor design and ensuring good-quality documentation as failure to do this leads to higher costs, increased litigation, schedule delays and lower quality of the final constructed product.

Research has indicated that material and information flows, and the generation of good value for the customers and end users involved within the design process, as well as transformations of inputs to outputs, are achieved effectively using a lean design management approach (Tilley, 2005). However, the complexity of the relationship between the fundamental principles of project management and the transformation model/theory of production work as obstacles which hinder the process of finding effective solutions to failures to manage the design process; this can result in poor levels of performance (Tilley, 2005). There is need to consider the nature of design and whether or not design development can be considered as part of production when considering the concept of lean design management. Improving the integration of project processes, design and construction have been identified as a key to the successful outcome and performance of a project as design cannot be considered separately from the construction process (Jørgensen and Emmitt, 2009; Brookfield et al., 2004). Thus, in order to achieve more efficient and better quality outcomes, Lean Design Management (LDM), or more specifically the introduction of ‘lean production’ principles to the process of design, has been promoted as a new approach (Egan, 1998).
However, due to inadequate design management and poor quality control of an end-product, together with problems concerning quality and efficiency experienced during the design process, there is a need to apply lean principles through design process to improve the quality of outcomes for the customer while, at the same time, reducing costs and resources through waste reduction (McCarron, 2006; Tilley, 2005). Moreover, these principles can be used to manage the development and production of documents, which become more and more detailed, until they reach a stage where they are suitable for use in planning, budgeting, estimating and eventually constructing (Tilley, 2005; Koskela, 2004).

Generally, the keys in ‘thinking lean’ are defining waste and speculating exactly what is of value within the organisation: i.e. precisely what activities and resources are needed. It is important to consider only those that are needed for the owner, client or end-user because including others is considered as waste (Poppendieck, 2002). Out of seven types of waste identified, only six can be considered to be within the construction design management process (transportation is not relevant):

- Extra tasks, iteration (Overproduction)
- Extra resources (Inventory)
- Each design member has to report to a coordinator who reports again to other design participants (Extra Processing Steps)
- Tasks flow on time (Motion)
- Lack of briefing (Defects)
- Customer responding (Waiting)

The main approach of any lean design management strategy should be to maximise the overall value for clients and end-users from the project, while maintaining a high level of performance from the design process. Jørgensen & Emmitt (2009) found that the successful application of lean was highly dependent upon the individuals involved and their ability to apply lean to the various aspects of projects. Issues such as communication problems in terms of inadequate briefings, client complexity, design time being shared equally between the architect and the engineers, and design team value not being fully considered by architects, have indicated that most waste occurs because of the practices in early design stages, but this is an area largely overlooked by researchers in the lean construction community. More focus is needed on identifying waste in architectural design, together with reasons why it occurs.
3. METHOD

The literature review was useful in helping to establish a lack of knowledge and understanding of lean design management. To help address this shortfall it was felt that a questionnaire survey would be useful in gathering the opinions of a wide range of professionals. A questionnaire survey was designed to collect qualitative and quantitative data and piloted on a small number of volunteers, following which a small number of revisions were made to aid the clarity of the questions. Questions were organised under a number of themed headings, namely background information, highlighting the issue, evaluating communication techniques, design management process formation, the implementation of lean management, and further comments and information.

The questionnaire was sent to 908 construction industry practitioners working in design companies and construction organisations, comprising: architects, design managers, project managers, coordinators, engineers and quantity surveyors.

A total of 163 questionnaires were returned, although not all were fully completed and therefore a decision was taken to exclude the incomplete questionnaires. This resulted in a sample size of 125 fully completed questionnaires. Responses were from a variety of industry practitioners (17 architects, 15 design managers, 38 project managers, 5 coordinators, 28 engineers and 12 quantity surveyors). However, it must also be stated that 10 responses were considered reliable as their responses to the other survey questions suggested that they actually carried out a role in the construction industry. It was discovered that their roles were not included in the categories provided as some of them stated their position in the optional section, headed “Further information”, at the end of the survey questionnaire. These roles were key account director, marketing manager, managing director and director of architecture.

A mixture of qualitative and quantitative data were collected; these expressed a diversity of experience and views in terms of the inefficiencies in the current construction design management practices and the implementation of a lean management approach in design processes, processes that are intended to manage the design stages efficiently, therefore ensuring the delivery of optimal value (in terms of the product/building) to the customer or client. Although the intention was to collect data from clients only two responded, and only one of these questionnaires was complete. This made it impossible to draw valid judgments concerning differences or similarities between the responses of clients and those of the industry practitioners.

4. RESULTS

Generally, the analysis of the data collected from industry practitioners from the survey questionnaires demonstrated that there is inefficiency in the design management practices in the UK
construction industry because of the poor design management processes. As a result, many construction projects are delayed and go over budget; in some cases, clients are also not satisfied with the final building. However, the data analysis illustrated that procurement methods are also responsible for inefficiency in the early design stage. The results presented below relate to the use of lean design management.

### 4.1 Inefficiencies in the design process (waste)

This study found that inefficiencies exist in the design process because of the nature of the process itself and the ways the design process is managed. These inefficiencies generate waste that must be mitigated or preferably eliminated. This waste results from human activity and current applications of design management.

It was found that the waste experienced in design processes is generated through the late approval of decisions by clients, resulting in a creeping escalation of a project’s scope. One engineer stated that: “The adage 'fail to prepare, prepare to fail' is very true with most things, especially construction”. Clients are often accused of causing inefficiencies because of vagueness in the content of the client’s brief and difficulties associated with securing their approval. Clients have also been criticised for failing to appreciate that a change during the design stage can potentially result in a complete redesign. One project manager claimed that: “Clients generally have no understanding of the commissioning process. They leave everything to the last minute then expect consultants/project teams to pull a rabbit out of the hat”. Clients are blamed too in terms of their side commissioners as, in most cases, they have no background experience regarding what they are commissioning and do not listen to the consultants they are paying to give them advice. Broadening the distribution of value to different stakeholders may therefore be achieved by gaining a better understanding of a client’s complexity (Tilley, 2005; Emmitt et al., 2005; Koskela et al., 1997).

Further waste is generated through poor design management (e.g. a lack of an efficient flow of information and overly complex designs; the brief may be poorly interpreted, the construction strategy might not be communicated early enough, and too many design alternatives might be offered etc.). Furthermore, design teams often do not appreciate that many clients are inexperienced, as one architect reported: “Clients can be trapped by their own decisions. It is the responsibility of the design team to fully appraise the client on these factors and ensure deliverable decisions are made”.

Far more waste is generated through the briefing (the main communication tool) because of inadequate brief documents and brief freezing. The client in a construction project is an integral participant in the design process, unlike in product design or manufacturing. One project manager claimed: “Design in construction is a complex problem and is not amenable to a single correct solution. The design team and the client's understanding evolves with time, therefore it is impossible
to define all the requirements at the outset of a project (the fallacy of a 100% brief). The search for solutions is iterative over time and must embrace bounded cognition (on all sides), increasing but imperfect knowledge, and be focused upon achievement of a satisfactory outcome”. What is more, clients are asked to put forward all of their requirements early on; as a result, clients are directed to make assumptions and therefore, designs are worked out based on soft assumptions that are liable to change. One engineer stated: “It cannot be expected that the design team can have the final solution from early on in the design. If that was the case, innovation and accurate design will not develop”. However, two main objects were also stressed: first, having a clear initial design brief to give a project a strong start; and, secondly, organising briefings in phases, in line with the development of the design. It was felt that some information should be frozen at gateways to phases; changes in the frozen information should not be allowed beyond these points as making processes too flexible can cause problems. However, the key is to freeze information at the right time when the right information is there. The respondents also pointed out the need to freeze phases as a way of measuring and managing any changes.

On the other hand, some participants claimed that briefing must remain fixed as a successful design requires the solid foundation of clear client requirements. One engineer stated: “If the brief is vague then a range of options must be considered as acceptable”. What is more, this type of briefing acknowledges changes in terms of both the budget and time as it acts as a benchmark against which the design is judged. One project manager stated: “If the brief is continually changing, the client must accept that the costs will change to go over budget. A completed section of work is destructive to a design team’s morale because of brief changes”. Another view was that, having briefings as a continuous process, might lead to a failure to concentrate on some early key issues. However, there is definite emphasis on fixed briefings at Stage D of the RIBA. One architect stated: “After a certain point, ‘development’ of the brief becomes change as an architect should assist the client to develop and modify the brief in the early stages of the project, as their requirements become clearer, or as the developing design throws up issues”. However, it should be stated that necessitating changes results in a better product (i.e. building) in terms of more value to the client, but in less value for the construction or design companies.

Planning design activities and allocating appropriate time for each has been addressed by this research. Most organisations in the UK tend to plan design activities in a similar way to construction activities; this is by using the critical path method. Very few carry out procedures in line with the process, such as peer design review workshops, where the design team members work out all the interdependencies in order to ensure that all parties know what they are delivering, to whom, and when.
Generally, the respondents argued that the aim is always to complete the design as early as possible but design time is controlled by several parameters, such as the business case (the procurement method), the complexity of the project, the project’s value, legislation and planning permission, deadlines imposed by clients, and the ability of the client to participate in the process. Furthermore, design time is allocated for each activity and this is based on experience rather than being based on a standard scale: e.g. productivity. This approach, without doubt, contributes to inefficiency in the design management process as the time for design activities is guessed at instead of being accurately allocated.

Some respondents expressed the view that it is necessary to employ a combination approach as design is different from production. Design is iterative, not linear, and therefore requires flexibility by allowing the consideration of various options, together with development based on assumption. The design management process is a chain of activity but there is a need to allow ‘loops’ within the process to allow for the review and evaluation of different proposals and alternatives. The reality of project timeframes requires that a design should be developed through three key elements: imagining, presenting and testing (Koskela et al., 1997). However, it must be stated that design time can be estimated or guessed only within the concept design stage as this is a creative stage based on mental activity which cannot be measured. At this point, the design ideas can still be played with to develop alternatives, unlike in other design stages where the ideas are prepared for execution and the process depends on people’s ability and the resources available.

One of the major findings of this study was that inefficiency in design stages occurs through deficiencies in the procurement method. It was found that design and build procurement has encouraged some early design issues to be ignored. This is mainly due to the general belief that design and build will allow uncertainty to be addressed later in the construction phase; this lack of accuracy, with the hope that ambiguity will be addressed at a later point, also appears to hinder the application of lean construction management.

4.2 Value stream

Another major finding from the study was that the UK construction industry suffers from a lack of awareness of the diverse nature of value and the importance of managing a three-dimensional construction value (i.e. the value of different clients or stakeholders, end users and the project team). One design manager claimed: “No one defines ‘value’ or how it is measured. Value is different for different clients”. There is a need to understand each element of value, as minimising waste alone does not guarantee the overall success of a project (Emmitt et al., 2005). Value differs from client to client and from organisation to organisation. Value for a client could equate to cost, time, function, sustainability or aesthetics, while value for an organisation could be time, profit, repeat business or
being well known. Value also differs from project to project: e.g. value for a show-piece project is not the same as for service or trade projects.

The study demonstrated that work productivity, in comparison to efficiency, is generally the most important criterion for measuring a company’s performance in terms of value. Moreover, the value stream in most organisations is not identified. However, some organisations claimed to identify value by looking at the following: opportunities, value delivered to the client's business, monthly projected income, customer feedback, risk analysis and successful credits gained at project stages and a few make use of some techniques such as value stream mapping, and KPIs.

4.3 The implementation of lean management

Another major finding of this study is that almost three-quarters of the sample was not utilising any specific approach to improve organisational performance in terms of the value delivered to the client and for waste reduction; only 15% of the sample is currently utilising the lean approach. Those that were using a lean approach claimed that the lean management philosophy was integrated with design management process through systematic routes, such as:

Ensuring the early engagement of all critical parties, designers, contractors and suppliers.

Reviewing collaboratively to agree about critical stages, to generate an action plan and to monitor jointly buffer usage to achieve certainty of delivery.

Detailing improvements and lean applications. Open workshops are also used where each process is checked against other similar projects and new ideas and concepts are introduced.

Making services as efficient as possible through the use of innovative technologies and management techniques.

Educating the project team in lean philosophy and encouraging them to adopt it in their commissions. There was agreement within the sample that the time invested in the pre-construction stage would reduce waste generated in the later project stages (because of incomplete briefing documents), eliminate cost overruns, and allow both efficient construction and high-quality production. However, there were two different approaches to this. The first group of respondents noted, as stated by one project manager: “Better management towards a ‘right first time’ culture”. As the brief is part of an early stage of the design process, so the key is to make it as project deliverable; therefore, the brief should be a clear and concise document, delivered as early as possible. The respondents argued that a good brief can be achieved through achieving the early engagement of all the major players and allowing the client sufficient time to ensure all requirements are identified.

Conversely, the notion that, as stated by an architect: “The current culture demands everything now” was blamed for waste by the second group of respondents. They argued that briefing documents need to be aligned to design stage gateways, which are then signed off by the client. In addition,
briefing documents at each stage need to be relevant to the information required. This can be achieved via user input throughout the project to ensure the brief is kept up to date. Furthermore, reporting at the end of each stage and filling gaps with missing information; establishing 'design cut-off dates' when, up to a specific date no costs are incurred; and then making clear that, after the 'client sign off' date, the client can expect costs for changes; these will all reduce waste.

Both groups emphasised the necessity of improving the quality of the brief by educating both designers and clients on the preparation of a clear brief and what this will look like. One architect stated: “They may not know the question until you ask it” so, providing benchmark guidance to the client and informing them clearly of their duty and responsibility for the brief, should be clarified to facilitate the production of a complete brief. The client must understand that ambiguity will result in delay and/or waste. Clients have to appoint suitable representatives who have relevant experience; these representatives must be briefed and made aware of how important decisions are, together with what the consequences are of not making or changing decisions.

In general, the comment on applying lean management to the design management process stated that lean management does not automatically mean that the process takes less time. Applying lean management is a costly process and most people will not venture into it as there is no a clear-cut desire for “value for money”. Another comment suggested that each process has its own characteristics so lean management needs to be customised to the process to which it is being applied. For example, the traditional procurement methods used by most construction companies hinder the lean construction process.

5. DISCUSSION AND CONCLUSIONS

The research has revealed a number of shortcomings in the design management processes and practices in the UK construction industry, and, more specifically, in processes at the scheme design stage. This can be traced back to inefficiencies in managing the design process. This finding is in line with the results of previous studies that claim that delays in projects, budget overspends and, in many cases, less value being delivered to the client, are related to the early design stages (Bertelsen and Emmitt, 2005; Hansen and Vanegas, 2003; Tilley, 2005). However, analysis of the data illustrated that procurement methods are also responsible for inefficiencies in the early design stage of projects. Findings also reveal that inefficiencies in managing the design process may have hindered the advantages of employing lean concepts. Clearly there is a need to improve the integration of project processes (Jørgensen and Emmitt, 2009; Brookefield et al., 2004; Bogus et al., 2000) and client briefing (Hudson, 1999).
Achieving efficiency is complicated due to several factors associated with the nature of the design process. These factors include the fact that many disciplines participate in the process; and clients (customers) are external parties in relation to the company. Clients initiate the design process and play a role as an integral control element; being the business generators and primary decision-makers. This differs from mass manufacturing, where clients or customers are not actually involved in the product design because they are not yet, at this stage, truly clients or customers. Their needs (desired value) are considered in the design but they are not directly engaged in the design process, and hence are not decision-makers in the design process. Indeed, even in car manufacturing, where lean concepts have been applied successfully, when the client wants to customise his/her product, the design process will be affected and it must be accepted and appreciated that extra cost and time must be allocated in order to achieve the desired value.

Lean design management appears valid for implementation in construction projects, but only if the concept of customising each application is considered. This depends on the client’s requirements, whether something is needed urgently, or if the project is a showpiece with fewer limitations on time and budget. In other words, lean design management needs to be customised in terms of the value of the desired project. However, to develop clear-cut decisions, there is a need for each value track to set out a general plan of lean design management that can be tested through case studies and programme monitoring.

With the benefit of hindsight, one of shortcomings of this research was the failure to define fully a starting point where a design organisation might apply lean-thinking management without interruption. From the data, it was felt that lean thinking management could be implemented starting from the design development stage (i.e. the scheme design stage) but it is recognised that in order to develop a better understanding face-to-face interviews and monitoring of live projects would be necessary. From this is may be possible to develop a generic process plan for lean design management, which could then be tested on projects be tested through case studies and programme monitoring to explore whether lean design management is applicable for all types of projects in the AEC and what, if any, characteristics relate to certain project types. Further research is also required to explore the experience and views of clients and the early engagement of other professionals with lean thinking, such as structural and M&E consultants. Additional research is also required to establish to what extent current deficiencies in the management of the design process influences the value delivered to clients and building users.
6. REFERENCES


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