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LEAN DESIGN VERSUS TRADITIONAL DESIGN APPROACH

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ABSTRACT

The purpose of this paper is to determine if lean design can enhance value for the customer in the construction industry based on an examination of the design phase. Resent research from Statistics Norway shows a reduction of 9 % in the Norwegian construction industry's productivity from 1992 to 2012. The paper also discusses if lean design can have an overall positive effect on the productivity. A case study has been carried out, comparing two projects using a qualitative approach. The projects use different methods in the design phase; lean design vs. traditional design approach.

Implementing lean design can increase value for the client. Lean design might enable a productivity growth in the Norwegian construction industry similar to the growth observed until the 1990s. Similarities are found between classic project execution and projects where lean design is implemented, particularly the focus on planning and control. The originality lies in comparison of the recently implemented lean design and the classic project execution model. This permits an in-depth analysis of the novelty and effects of certain lean design features. Lean design seems to have reduced waste in the process, but the total value concept was rarely considered.

KEYWORDS

Value, lean design, productivity, lean construction, waste.

INTRODUCTION

Project management have traditionally been concerned with cost, time and quality when measuring success in a project (Atkinson, 1999; Cooke-Davies, 2002; Hjelmbrekke, et al., 2014). According to Fewings (2013) time, cost and quality are the three dimensions of control and represent the specific project efficiency factors. He further claims they are managed for the satisfaction of the customer's requirement, but are secondary to the customer's business needs. The prime concern for the project manager in a construction project is rather to create value for the customer.

Resent research from Statistics Norway shows a reduction of 9% of the productivity in the construction industry in Norway over a time period from 1992 to

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2012 (StatisticsNorway, 2015). The statistics also show an increase in the productivity in the manufacturing industry over the same period of time. Errasti, et al. (2007) claim that this increase results from integrated flows and processes in order to create value for the customer. They conclude that the construction industry has a lot to learn from this culture. This might also indicate that the construction industry has great potential for improvement.

In recent years, working methods such as lean construction have been introduced in the Norwegian construction industry. LCI (2015) defines lean construction as a production management based approach to project delivery. They further claim that the reliable release of work between specialists in design, supply and assembly assures value is delivered to the customer and waste is reduced. Emmitt and Ruikar (2013) argue that to ensure that maximum value is created and waste eliminated, the design phase must be managed effectively.

The literature review preceding this paper found a surprisingly small amount of studies devoted to the comparison of traditional and lean design approaches in light of value creation. To fill this knowledge gap, that is, to evaluate if lean assures added value is delivered to the client, it is essential to compare lean to the existing approach.

The study is based a comparative analysis of Bergen Academy of Art and Design (the Academy) and the New Norwegian National Museum of Art, Architecture and Design (the Museum). The Academy implements lean design while the Museum uses a traditional project execution approach. The ambition of this paper is to assess to which extent lean design can enhance value for the customer in the construction industry based on an examination of the design phase. It is examined how the distinctive stakeholders deal with the value specification as an outcome of the architectural competition. In order to address this issue, we attempt to answer the following two research questions.

- What are the characteristics of the two different design approaches?
- What are the advantages of the different approaches?

METHOD

The study leading up to this paper was based on a qualitative research method. A case study approach was chosen, in accordance with the procedures outlined by Yin (2013), examining two major construction projects in Norway. A literature study aiming to identify main features of project planning using lean design principles was carried out. The objective of the analysis was to compare these with design phase principles used in so-called traditional project planning within the Norwegian context. Several scientific databases were searched in order to identify papers bearing on lean design, value, value creation and design approaches to compare traditional and lean design in this context. A document study was executed on both projects. A pilot study of the Academy was conducted in the fall 2014, with three interviews. The pilot study was later used to shape the research questions in this article. The case study of the Museum and the Academy was carried out in the spring 2015. Five semi-structured open-ended interviews were carried out with the project manager in the Museum and senior design managers from the architects and the consultant engineers of both projects. The plan for future research is that this paper forms part of an on-going research of lean projects in the Norwegian context.

THEORETICAL FRAMEWORK

VALUE

The fundamental purpose of a project is to create value for the customer. Not surprisingly, value discussions constitute a major role within lean theory.

Several definitions of value with different perceptions exist. Kelly, et al. (2004) define value as function divided by cost. Bowman and Ambrosini (2007) on the other hand look at customer value as consumer surplus. Consumer surplus is defined as when a consumer derives more benefit (monetary value) from the good, than the price they have to pay. In this way it is distinguished between how the customer values the good and the actual price. Emmitt and Ruikar (2013) define value as a measure of the beneficial return gained from the consumption of resources.

Hjelmbrekke and Klakegg (2013) define value creation as a result of human activity. Thyssen, et al. (2010) maintain that during the construction project the involvement of different stakeholders will change and also their values and perspectives. Due to the change process and the nature of human behaviour, the change of perspectives will be unpredictable. This makes value management in construction a difficult process. Hjelmbrekke, et al. (2014) claim that in a construction project, value can be separated into the project output value and the use value. The project output value is the building measured on cost, time and quality. The use value is the effect of the project output on the core business. It reflects what the client is prepared to pay for the finished product when the various solutions are known. It is essential to consider how the customer evaluates the product to meet their needs (Hjelmbrekke and Klakegg, 2013).

Value and lean

LCI (2015) defines value as what the customer wants from the process. Salvatierra-Garrido and Pasquire (2011) recognise that the lean construction perception of value has, to a great extent, been influenced by lean production as manifested in the manufacture industry.

Koskela (2000) identifies three main causes that decreased value for the project customer: value loss due to poor project management, value loss due to design and value loss due to construction. He further claims that customer requirements can be unclear concepts that need to be addressed through the whole life cycle in the construction project.

Hines, et al. (2004) highlights that lean construction has developed from a waste reduction focus to a focus on customer value. They maintain that value for the customer can be increased by reducing internal waste, develop customer value or both.

Emmitt, et al. (2005) define value as "*an output of the collective efforts of the parties contributing to the design and construction process; central to all productivity; and providing a comprehensive framework in which to work".* They separate the perception of value into two conceptual phases: value design and value delivery. In value design it is established and reflected alternatives for conceptual design. By attaining agreements between participants and providing the best design solution, the uncertainty is reduced. In value delivery the chosen design alternative is transformed into a production design. The aim is to deliver the specified product in the best possible way, with minimum waste.

Salvatierra-Garrido, et al. (2012) found in their research of the value concept as commonly perceived within the IGLC community, most efforts have mainly been endeavoured to deliver value at project level, where waste reduction and planning and control of construction site activities have been key activities linked to value. Several efforts have endeavoured to fulfil particular customer's requirements. A reason for this might be that it is easier to consider and measure waste in a project that consider value, since value is a complex concept.

The client wishes to both increase the total value and reduce waste. In this paper value is assessed from two different perspectives; increased use value to maximise consumer surplus and increased consumer surplus by reducing waste.

PRODUCTIVITY

Productivity can be defined as a measure of the ratio between produced quantity (output) and input (Forbes and Ahmed, 2011). An increase in the productivity implies that a certain amount of input enables the production of more quantity than earlier. In the construction environment productivity may be represented as the constant-in-place value divided by inputs such as the cost value of labour and materials (Badiru, 2005; Forbes and Ahmed, 2011). Forbes and Ahmed (2011) state that recognizing the need for improvement through productivity measurements, performance improvement over time can be achieved. Oglesby, et al. (1989) maintain that traditional construction management tools do not address productivity, mainly just cost overruns and schedule slippage. Forbes and Ahmed (2011) maintain that performance is often measured in terms of completion on time, meeting construction codes and within budget. By just meeting the construction codes, the owner/client satisfaction is rarely considered.

In this paper productivity functions as the constant-in-place value divided by inputs. By reducing waste in the process, an increase in the productivity might be achieved. An increase in the productivity will thus affect the project output value.

DESIGN APPROACHES

Traditional design approach

PMI (2013) identifies tasks for the planning process group to develop a project management plan, plan scope management, collect requirements, define scope, create a Work Breakdown Structure (WBS), define and sequence activities, estimate activity resources and duration, develop schedule, plan cost management, estimate costs, determine budget, plan quality, develop human resource plan, plan communications, plan risk management, identify risk and perform risk analysis, plan risk responses, plan procurements and stakeholders management. According to Wysocki (2014), in traditional planning a central element is the Joint Project Planning Session (JPPS) where stakeholders up front develop the detailed plan. The end result is an agreement on how the project can be accomplished within the specified time frame, budget, resource availabilities, and according to client requirements. The deliverables from the JPPS are WBS, Activity Duration Estimate and Resource Requirements. A Project Network Schedule can be created from the WBS. It defines the sequence in which the project activities should be performed. The output of the activity schedule will be the assignment of specific resources to the project activities.

Lean design

Forbes and Ahmed (2011) maintain that in lean design constructability reviews and value engineering are continually integrated with decision-making. This is achieved with cross-functional design teams that include architects, engineers, contractors, and subcontractors among others. Emmitt, et al. (2004) found that through the use of creative workshops, which encourages open communication and knowledge shearing, the project participants claimed that the lean design process was contributory in delivering value and improving productivity.

Fewings (2013) claims that when front-loading the resources in design in order to eliminate waste efficiently in manufacture, success can be obtained. Such front-loading can be achieved by doing the planning ahead and arranging simultaneous working between the design, manufacture and supplier. To have a reliable database of products, systems and components is of importance in order to use learned systems for new products and design. Ballard (2008) highlights that it is central that the customer gets involved early in the process. The customer should be shown different alternatives for realization of their purposes and be helped to understand the effects of their requests.

Different tools often used in lean design are Target Value Design (TVD), Set Based Design (SBD) and Choosing by Advantages (CBA). The Last planner system (LPS) is a collaborative and commitment based planning system. Last planner system is based on the Should-Can-Will-Did principles (Ballard, 2000). According to our understanding, LPS can be divided into four levels of scheduling and planning notably master schedule, phase scheduling, look-ahead planning and weekly work plan (Ballard and Howell, 2003; Ballard, 2000). Learning is a significant part of LPS (Ballard, 1999; Ballard, et al., 2003; Ballard, 2000). Reasons for non-completion can be identified through Plan Percent Complete (PPC) (Ballard, 2000). PPC measures the percentage of task completed relative to the planned tasks. It is a measure on how well the planning system is working (LCI, 2015).

FINDINGS

There were only considered qualitative data in this comparison, due to the lack of available quantitative data.

Table 1: Overview of the distinctive projects

Facts	The National Museum of Art, Architecture and Design, Oslo	Bergen Academy of Art and Design
Design Approach	Traditional Approach	Pilot project in lean design (detail design)
Cost framework	5.327 billion NOK (01.07.2013)	1.065 billion NOK (01.07.2014)
Volume	Ca. 54,600 m^2	14,500 m^2
Construction start/end	2014/2019	2014/2017
Phase spring 2015	Detail design/construction	Detail design/construction
Client/Owner	Ministry of Culture/Statsbygg	Ministry of Education and Research/Statsbygg

BERGEN ACADEMY OF ART AND DESIGN

In the Academy, the design team consists of the architect Snohetta and the general engineering consultant Ramboll. Statsbygg decided to implement lean design in the detail design phase to improve the process. The design team was given intensive courses to be familiar with lean construction principles, but neither the course holder nor the design team had any experience with lean design. Statsbygg regarded the project as a pilot – and a specific model of how to implement lean design was established. The project was divided into four levels of planning:

- Level 1 it was the project level where there was prepared a Product-Creation-Process (PCP)-plan. This was a static model with sub-processes. The PCP-plan contains few milestones with wide timespans. Responsibility and rolls were defined at a general level.
- Level 2 was the sub-processes of the PCP-plan. An example of a sub-process is the designing. The design plan was divided into parallel and sequential task with milestones. In this level the responsibilities and rolls were distributed.
- Level 3 was a multidisciplinary theme. It described what the product was and when it was needed. One person was responsible for each theme and in charge of "pulling" in the information.
- Level 4 was a disciplinary activity.

Each phase in level 3 comprised a sequence of 14 days workload. The design team had a time-restricted co-location, where owner, consultant engineer and architect were located in the same office three days every 2nd week. The co-location included reserved time for the stakeholders and project team to report what they had done, what the issues were and what information was required. Visual planning was used. Meeting minutes were used sparingly – mainly theme logs with connecting deadlines.

There was a focus in the project to establish lean as a planning culture where mind-set, a course of action, a way of being or an attitude change, were essential aspects. TVD, SBD and CBA were not considered in the project, even though there were used some elements of these.

The breakdown structure in the detail design clarified the distribution of responsibility. This had a positive influence on keeping the right pace and flow in the project. The team kept up with deadlines. The decisions were made in plenary sections with the owner (Statsbygg) as the main responsible. The design team used a common BIM model for quality control and clash detection to obtain zero defects. The common BIM model ensured transparency, which created pull in the project. A good planning process and frontloading resulted in what was regarded as success. There was a mutual agreement that the use of lean methodology resulted in a good team spirit and teamwork. The time-restricted-co-location had a positive effect on collaboration. The introduction of new team members without lean experience resulted in waste due to the lack of adoption of the actual design method.

The mix of fixed price contract to Snohetta and pay by hour in Ramboll had positive effects. Architects focused on decision-making and efficiency and engineers feed resources to keep up with deadlines. The coordination within the team made an extensive utilisation of resources possible.

The design team had a focus on continuous improvement and learning from past experience, including regular assessment of on-going work and methods.

The project manager (PM) observed just minor cost deviation in the first package of tenders from contractors. This indicated that the deliverables of the design held the required quality. This was explained as a consequence of the use of lean methods. The design phase was going to be completed one month ahead of schedule. The PM has experienced that design is often more comprehensive than originally planned. The PM believes the process breakdown into time-restricted activities and focus on the flow in the detail design in the Academy project has contributed to a better product.

One major characteristic of the Academy was the intensive use of resources and knowledge in the design phase. This was expected and believed by the design team, to facilitate a more efficient construction phase with less errors and delays.

It proved impossible to obtain whether the lean process has resulted in a more effective construction phase and if it pays to invest in the design phase at the stage of our inquiry. Until now, the project has not undertaken any measurements regarding performance. The PM believes they have implemented lean in a right way so far. He considers they could probably have made more efforts to succeed, but that becomes a cost/benefit issue.

THE NEW NATIONAL MUSEUM OF ART, ARCHITECTURE AND DESIGN

The Museum project used Statsbygg's project execution model based on traditional project management models. The owner, the consultant engineer and the architect were located at a project office. The designers reported to Statsbygg every month. Originally they worked sequentially, but because of delays they started to work in two parallel plans to meet the project deadlines. The architects, Kleihues + Schuwerk as well as the consultant engineer, Ramboll had a paid-by-hour contract. The architects were organized in a hierarchy, with a few lead architects being responsible for general design. Their main working principle was to have all solutions ready before involving the engineers. The architects and the engineers stand as equal in the project.

The quality level of the planning was perceived to be high. The joint project team follows the main schedule and the functions and tasks of the different team members seem to be clear. To prevent misunderstanding, improve collaboration and encourage integrated solutions, a project office was established. This co-location was not regarded as a contributor to collaboration and value-in-use of the asset.

The architects as well as the engineers experienced that the personal relations within the project team were not optimal. They experienced a lack of an owner "decision maker" involved in the process, due to frequent situations where the design team was not able to get to consensus on an issue, but were still asked to solve it.

Statsbygg had an in-depth user survey in the front-end of the detailing phase, which required several modifications. This survey was initially scheduled to the initial phase, but due to formal problems the survey was postponed. The consequence was redesign in the detailing phase to align the solutions with user needs.

The available time frame for basic design was thought to be too limited. This resulted in what was regarded as superficial design, which in turn led to a need for an extensive rework and redesign in the detailing phase.

The consultant engineer experienced that the stakeholders in the project were not learning from experience and incidents earlier in the project**.** It was regarded as a general problem to provide the project with the required resources and competence, due to owner budget constraint as well as shortages in the project teams. From experience, in projects of this size, involved parties should have an organisational

capability of at any time supporting the project with the required resources to ensure quality of deliverables as well as being within the time schedule.

DISCUSSION

The Academy project was characterised by clear distribution of responsibility, front-loading and focus on planning. This has resulted in flow in the process and quality of the design. The team members had the ability to make decisions in accordance with the requirements and keep up the project pace. As a result, the project kept up with deadlines, completed the design phase earlier than expected and was able to avoid delays. Visual planning, co-location and common BIM model contributed to transparency. This resulted in a common understanding of all stakeholder's objectives and superior collaboration.

In the Museum there were observed several conflicts between engineers and architects regarding design. The lack of a visible project governance and leadership was frequently mentioned as a problem. There was a general perception that more resources should have been deployed in the initial phases to avoid waste as a consequence of rework and redesign. In the Academy on the other hand, the stakeholders have been pleased with the amount of resources.

The Museum uses some of the same elements as in the Academy, such as having a project office. The collaboration in the Academy was perceived as very good, but not as good in the Museum. The lean approach and the collaboration to meet the project objectives appear to have given an improved process. The fact that the Museum was a lot larger and complicated project might be a source of error in the comparison.

The Museum and the Academy were both working on increasing productivity, with the idea that improved productivity would result in increased benefits for the client. The main driver of productivity was identified as early and good planning. Stakeholders in both projects were of the opinion that better planning and design should increase the performance – which in the end should deliver increased value. It seems that the Academy project to a greater extent has succeed at this.

Table 2: Advantages of the different approaches

Project	**Advantages**
Bergen Academy of Art and Design	1. Dividing the project into levels and sequence of work loads
	2. Good planning process, front-loading and high focus on the design phase in terms of available resources and time relative to project size
	3. Team spirit, good team work and collaboration
	4. The mix of fixed price contract and paid by the hour
	5. Clear responsibility distribution and with owner decision-maker
	6. Transparency, working in an common BIM model
	7. Focus on learning from mistakes and continuous improvement
The National Museum of Art, Architecture and Design	1. Measuring project performance
	2. No need for education and comprehension of the project execution model and the used terminology to new project participants

Lean in the Academy was considered to contribute to increased value creation through increased transparency, resulting in a better realization of the participants' primary objectives and better collaboration. Lean design has created value by increasing the probability of completing the project within time, cost and quality through better planning. Use of more resources in detail design reduces waste in the design and was believed to reduce waste under construction. The involvement of the users was as in the traditional approach. It is notable that there was no increased attention on value creation regarding total monitory value for the client – but mainly a waste reduction focus.

CONCLUSIONS AND FUTURE RESEARCH

It is hard to generalize the findings when the study is based on design approaches in only two projects. In this case lean design seems to have reduced waste in the Academy due to the focus on process, collaboration and planning. This is noticed as promising because it might increase in the consciousness around excellent processes and planning. The total value concept (as defined in this paper) was rarely considered. A reason for this might be that lean design was first introduced into the project in detail design. In future projects using lean design, there is a potential to have more focus on total value by implementing lean design from the very beginning and also consider to implement tools like TVD, CBA and SBD.

Further research in this context should focus on delivered value, ex-post assessment of use value and benefits. This may give a broader understanding of advantages and disadvantages of lean design vs. a traditional approach.

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