INTEGRATED METHODOLOGY FOR DESIGN MANAGEMENT – A RESEARCH PROJECT TO IMPROVE DESIGN MANAGEMENT FOR THE AEC INDUSTRY IN NORWAY

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ABSTRACT

This paper presents a start of a research project which evaluates the design process as a two dimensional logic, which to some degree happens at the same time - in different phases of the process.

The two logics in question are as follows:

- The Sequential logic, which is the predictable process where the deliverables from each discipline within the design team are dependent of each other in a serial form. The development of the project thus happens gradually e.g. activity A must be finished before activity B can start.
- The Reflective logic, which is a more unpredictable process where the deliverables are interdependent of more than one discipline, in a reciprocal manner. The development of the project will not happen gradually, but more in leaps.

Recent developed methods such as "Set-Based Design" and "Set-Based Concurrent Engineering" are methods that have brought Lean thinking into the design process. These methods address the unpredictable with looking at several solutions at the same time and holding back the decision to the last possible moment. Lean Construction has introduced a production perspective to the design process with these methods. However, too much focus on the work flow (like Last Planner™), might shift the focus away from the client(s) needs.

KEYWORDS

Design management, design process, reflective logic, complex process.

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INTRODUCTION

The Norwegian construction industry has focused on implementing Lean Construction in the production process to increase their productivity. There has been several reports from implementation of methods like Last Planner™, showing some success (Kalsaas et al. (2009); Skinnarland, 2012). However, compared to other industries there has been a loss of productivity (Regionaldepartementet, 2011).

The production process is an important part of a building project as this is where the product is being made. Production is understood as an integrated process of designing and making in Lean Construction (Ballard, 2000b). The design process, however, is important for the whole life-cycle of a building (Aquino et al., 2002).

The design management is seen as the root cause of the problems with low productivity in the Architecture, Engineering and Construction (AEC) industry (Ballard et al., 1998). Tilley (2005) argues that poor briefing is an important part of poor quality and documentation deficiencies in the design process. Kestle et al. (2002) argue that the process has been too influenced by the sequential production view to actually generate value to the client. To respond to this, research has focused on understanding value and implementing different collaborative methods such as: "Set-based Concurrent Engineering" and "creative work shops" (Emmitt et al., 2005; Moe et al., 2010). However, Lean Construction has had a far greater impact on the production process than on the design process (Bølviken et al., 2010). We therefore argue that there is a need to further study the design process, in order to grasp its potential as a value generating process.

This paper marks the start of a four-year long research and development (R&D) project. The organization of the research project is composed of leading academic institutions and industrial partners. The group is mixed in order to represent the 3 key stakeholders in the process; client, consultant & contractor. The partners in the project are: Veidekke, one of the leading construction contractors in Norway, Cowi, one of Norway largest consultant company, the Ulstein Group an international shipbuilder, Nymo an offshore construction company, the Norwegian University of Science and Technology (NTNU) and the University in Agder (UiA). The industrial partners from the offshore and shipbuilding industries are used to complex projects. Even though these industries are different from the construction industry, we believe there is an innovation potential to compare these industries and develop new methods or "best practice" based on learning across the industries.

The R&D project aims to bring in new perspective by focusing on the reflective logic and the connection between the sequential and reflective logic in the design process.

There are two main objectives for the R&D project:

- To develop a theoretical based understanding of the design process in a construction based project.
- To develop a theoretical and practical based methodology for design management in a construction based project.

RESEARCH METHOD

The research method of this project will be a combination of theory development and research. New theories concerning the design process is expected to derive from

existing research and literature as well as through case studies of the design process at the different industrial partners in the project.

The research method will be carried out along two axes;

- Comparison of design cases related to construction based projects, by doing literature review from previously reported case studies.
- Comparison of design management between the AEC and shipping/offshore industry. This will be done by doing a literature review of design management and case studies of projects, including interviews of key stakeholders. The case studies will be conducted by the projects researchers at the industrial partners.

To strengthen the research 2 PhD studies and a professorship will be attached to project at NTNU.

THEORETICAL FRAMEWORK

The main idea of this research program is that the design process, - where decisions are made concerning the technical layout of buildings and constructions, - can be regarded to have a two dimensional logic that influences the process. The influence of the process will vary in the different phases of the design process.

- Sequential Logic is the predictable process where the deliverables from each discipline within the design team are dependent of each other in a serial form. This can be compared to the term sequential logic as it is defined in digital circuit theory; as a type of logic whose output depends not only on the present input but also on the history of the input. The development of the project thus happens gradually e.g. activity A must be finished before activity B can start as illustrated in Figure .
- Reflective Logic is a more unpredictable process where the deliveries are interdependent of more than one discipline. Kalsaas et al. (2011) describe this as reciprocal interdependence as illustrated in Figure . This is typically the early stages of a design process, and is an iterative process. The development of the project will not happen gradually, but more in leaps.

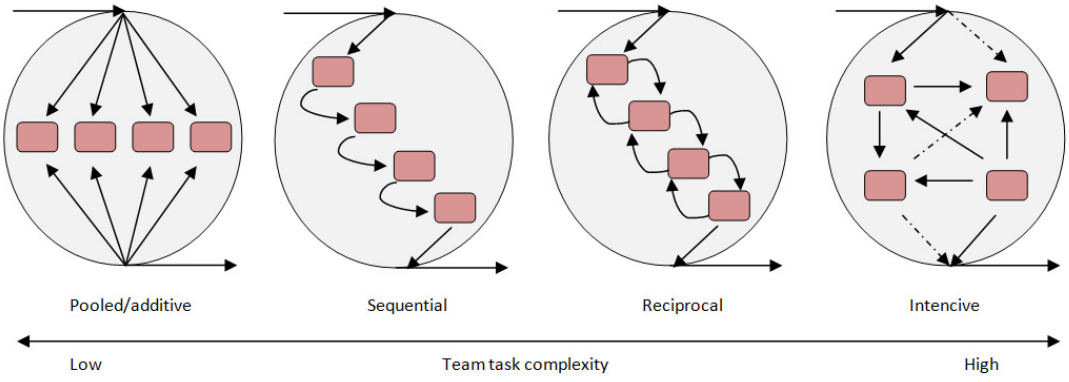

Figure 1: Different types of dependencies in team tasks (Andersen, 2011)

The combination of the two logics is viewed as a challenge for the design manager. When the design process follows a sequential logic, the design manager is able to handle it with good planning and coordination, as for most production processes e.g.(*A guide to the project management body of knowledge: (PMBOK guide)*, 2013). When the process does not follow the sequential logic, the process get unpredictable and hard to control, as described by (Morgan, 2006). An example of this is the relationship between the client, the user and the designer (Lawson, 1997) e.g. when a client or user does not know exactly what he wants; the different disciplines within the design team have to work with an incomplete basis and with the knowledge that their work might be changed during the design process.

It is our experience that as long as the design process follows a sequential logic, the design manager can use planning to support the control of the design process. It is when the process is non-sequential the design manager is really challenged.

For a design manager there exist roughly two methods for handling these challenges:

- To bring order to the system. The manager tries to plan and coordinate by viewing every unpredictable change to the plan as a failure of the planning and coordination of the project (Allinson, 1997). The manager will then try to implement even more control and planning into the process.
- To accept the unpredictable. The manager regards the unpredictability as a communication-, learning- and decision problem and implements measures to handle these problems (Morgan, 2006). The manager as a consequence has to practice a strong situational leadership.

To bring order to the system represents the traditional solution to gain control over the design process. Westgaard et al. (2010) emphasizes the importance of the design management and planning in order to get a successful design process. The report also views the development of new design management perspectives, both nationally and internationally, especially towards the Lean Construction community. This is partly done with reference to methods such as "Set-Based Design" and "Set-based Concurrent Engineering", where several alternatives are assessed at the same time and holding back the decision taking to the last possible moment (Koskela and Huovila 1997). The design and planning is viewed partly with a production perspective, arguing that the same techniques used in production management are valid for the design process (Ballard, 2000a). The methods of lean construction are primarily directed towards how production is performed.

Veidekke has adopted several of the Lean Construction techniques with good results. Especially the Last Planner™ techniques, which is used in almost all of their constructions sites. In their point of view, the Last Planner™ represents a necessity, but is not enough to ensure a design process with a good "inner" and "outer" efficiency. Inner efficiency is referring to the processes within the design process, while outer efficiency is referring to the process' importance to the building production process and the quality of the project itself (Eikeland 2001).

The value realization in a design process can be viewed from 3 different perspectives:

- To increase the inner efficiency of the design process: The cost for the design process is reduced due to increased efficiency for the design team. The value potential is marginal in the projects' scope.
- To increase the inner efficiency of the production process: The cost of the production process is reduced due to a better outcome from the design process. Drawings are flawless, delivered at the right time, and the solutions are buildable. The value potential is significant in the projects' scope.
- To increase the outer efficiency for the total process: The value of the project is increased, i.e. achieving a more functional, esthetical, technical and economical building. The value potential is significant in the projects' scope.

Improvements of the inner efficiency for the contractors, designers or suppliers, will reduce cost, which again can increase the competitiveness by lowering the rates or increasing the margins. Improvement of the outer efficiency could give more satisfied clients, which again could lead to increased willingness to pay, and to reinvest and to reengage.

Grimsmo (2008) described how to avoid design errors in Norwegian building projects and concludes that building projects can have considerable change in orders, from an 8% increase of contract value up to 20% for large complex projects, but only 8% of the change orders originated from the clients need for change. The same report also concludes that less design errors leads to lower building costs, a more predictable construction process, and a more accurate progress management. This clearly states the need for more efficient design process.

THE RESEARCH PROJECT

To achieve the main objectives of this research project there are four areas that will be of special interest:

1. Designing as a learning process

The client needs to play an active part in a project both in the development of the general design and in the decisions of details. The clients' involvement is an important success factor for a project (El. Reifi et al., 2013). Each project consists of new teams and new scopes, as a one-of-a-kind project (Koskela, 2000).

In the literature of Lean Construction the client value is linked directly to the overall principles to reduce waste in the value chain process (Womack & Jones 2003) The client value is more complex in a project base production, since the product is more or less unique. This leads to a value chain process resembling a learning process, where the key stakeholders exchange expectations, knowledge, and considerations, which through collective learning processes transforms to solutions and product. How can one identify the learning processes and facilitate them in such a way that they add value to the project?

2. The transfer of knowledge between design and construction

Design and drawings are just descriptions of the finished product. This indicates that there will always be an element of uncertainties in the construction process. It is during the construction process you will get the verification that the chosen design is

buildable, functional, and the value potential is realized. The goal to abolish the uncertainties as early as possible in the design phase might then be viewed contra productive, both for the design and the production process (Hansen et al., 2011). If drawings are merely viewed as a tool of communication, instead of a product to the construction phase, how will this affect the communication between the designers and the builders? What means can be used to enhance the transfer of knowledge between design and construction?

To develop buildable designs and drawings is a key topic in this part of literature concerning project-based production (e.g. Pulaski & Horman 2005). A main thought in this literature, is that the earlier and the more construction competence you bring in the design process, the better the drawings will be. Even though we believe this principle to be correct, there is only so much construction competence you can transfer through drawings. We assume that there must be other and better means to communicate and transfer knowledge between design and production, which better deals with the constructability in a design without all of this knowledge implemented in a drawing.

The use of Information and Communication Technology (ICT) in building design is a growing field in literature (e.g. (Khanzoode et al., 2008; Kunz et al., 2009), (Clemente et al., 2013)). In Norway several of the largest contractors, consultants, and owners have invested to get the development of ICT high on the agenda. Especially the Virtual Design and Construction (VDC) effort, - with its opportunities of simulating and modeling the planning, designing, producing and operating of a building, - have a potential to improve and increase the efficiency of the design process. The ICT technology will be a tool to support decision-making and a facilitator of the knowledge transfer between design and construction. We still regard this as a computer aided project tool, in which it is not enough to only visualize the interfaces to solve them, but in the context with personal involvement and collaboration, it will be a powerful tool.

3. Organizing systems of planning and decisions

There are many factors to consider in a building project, e.g. functional, technical, economical, and esthetical, etc. This means that a lot of important decisions must be made in cooperation, in different phases of the project. There will always be a risk that the different stakeholders sub-optimize their decisions to the disadvantage of the project. How can new ways to organize and manage these decisions processes contribute to a better interaction by the stakeholders of the project and at the same time increase the value of the project?

Virtual Design and Construction (VDC) with its ability to model the product, the organization and the processes, is a helpful tool (Kunz et al., 2009). The use of Integrated Concurrent Engineering (ICE) is seen as an effective way to reduce latency in decisions and to get a good interaction of the stakeholders (Kunz et al., 2009; Mark, 2001)

Measurement of learning, communicating and knowledge transfer

Drucker (2008) argues for the term controls meaning measurement and information:

a) Controls deals with facts, and facts are regarded as events from the past.

b) Control deals with expectations, and expectations are regarded as something that will need to be handled in the future.

In order to control the result of a process, you need measurements to let you know how your process is doing. How to develop means for measuring the process and the results, which can provide adequate information of the design team's achievements. The litterateur in this field is increasing e.g (Kristensen, 2013) discusses fourteen Key Performance Indicators (KPI) that are necessary to control a design process, and (Succar et al., 2012) five metrics for measuring BIM performance.

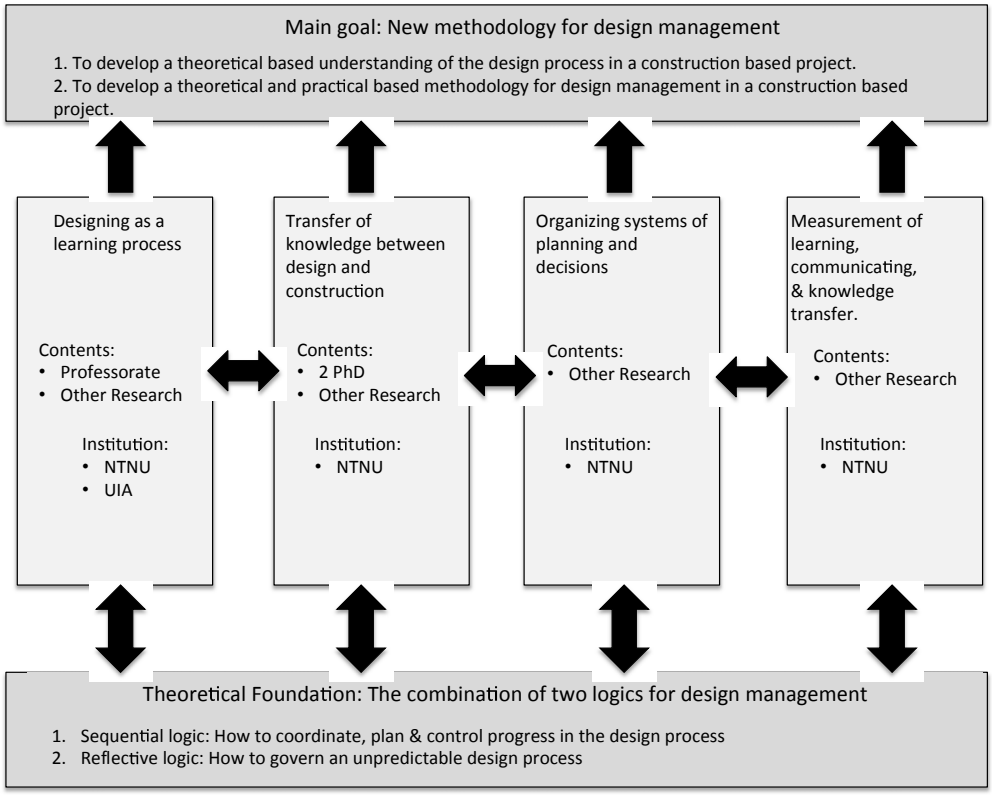

Figure 2: An illustration of the research project showing how the research areas interact with the main objectives.

CONCLUSIONS

We believe that the interaction today is dominated by a sequential logic, which results in design management as a pure planning and coordinating exercise. This is partly a correct assumption, but will be situational oriented. By viewing the design process as a two-dimensional logic with both the sequential and reflective logic, the design manager can better address the challenges in order to gain the most value from the design processes. Since project management techniques covers processes with sequential logic, there is a need to develop new methods for governing processes with reflective logic.

The main concern of this R&D project is to gain better understanding of the design process, and to use the knowledge to develop new and improved methods for

design management, which again will trigger an innovation and value potential in the AEC industry in Norway. By the project's end in 2017, we hope to present a new Integrated Methodology for Design Management. With this paper we hope to point out some of the issues this project addresses that needs further research and stimulate the discussion about reflective logic in the design process.

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