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Design management in the building process - A review of current literature

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Abstract

The architecture, engineering and construction (AEC) industry has experienced the declining productivity and some of this is due to deficiencies in building design. The focus on energy efficiency and sustainability makes it even more important to reduce such deficiencies. The managing of building design phases might be one of the most challenging forms of management in the AEC industry, i.e. it involves managing both outputs as drawings and creativity as minds. There must be enough room for creativity so that a building project can evolve to serve clients' needs. There are pooled, sequential, reciprocal and intensive interdependencies in building design that need to be handled or coordinated differently. A particular building design phase most likely consists of all the four types, yet dominance shifts between them through sub-phases. The logic of creative processes is difficult to understand and, therefore, to manage properly. In this paper, these four interdependencies and their coordination are described based on the literature review. The key findings indicate that the reliance on the same management approach to handle both reflective and sequential dependencies might be contra productive.

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Keywords: Building design management; interdependencies; review

1. Introduction

The architecture, engineering and construction industry (AEC) have a potential to increase productivity and increase the value of projects. There is a common apprehension that the overall performance of the AEC industry

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has not evolved with other industries and that there still are too many quality errors, leading to rework (e.g. Love et al., 2003; Love & Li, 2000; Meland, 2000). A finger is pointed towards building design as a major factor of low performance (Ballard & Koskela, 1998). Especially, the poor management of early design phases has proven to be the cause for document deficiency and rework (El. Reifi & Emmitt, 2013; Tilley, 2005). Moreover, it has been proven that these problems influence building projects as a whole negatively in terms of increased costs or reduced productivity (Baldwin et al., 1999). Similarly failures to fully understand clients requirements and value influence the value of buildings negatively in a form of clients not getting what they really need and want (Thyssen et al., 2010).

The term value is arguable for many definitions (Salvatierra-Garrido et al., 2012), but in this paper it is regarded in the context of owners, clients and users. Value can be regarded as something that improves a project, either as a final product or a successful process (Eikeland, 2001). It is in the early stages of the design phase where the influences of stakeholders is largest and the costs of changes are lowest, making this the best stage for value realisation (Samset, 2008). This stage is also most complex to understand, carry out and manage.

Many projects are not able to realise their value potential and this is argued to be due to managerial problems in the design phase (e.g. Hamzeh et al., 2009; Hansen & Olsson, 2011). One of the reasons for this is the complexity of the design phase, and especially the early design phase where iterations are essential for value creation (Ballard, 2000). The management of a mass production factory can always be planned sequentially, where activity A must be completed before activity B can start. This is seldom the case for building design management, where you want several iterations to generate value, consequently making the early stages of the design phase a complex process to manage.

In this paper, the processes of building design, the complexity of those processes and the most current practice of building design management are described, based on the literature review, as follows.

2. Conduct of the literature review

Compared to project management, there are only a few books written about building design management describing specific challenges in design management (Blyth & Worthington, 2001; Emmitt & Ruikar, 2013; Eynon & Building, 2013; Gray & Hughes, 2001; Sinclair, 2011). The research is mainly presented in papers and articles. In order to describe complexity, building design management is linked to organisational management.

The literature review was done by applying the seven steps of Creswell (2003). The topic words were building design management. These were chosen to give understanding of the amount of literature with those keywords. The search of relevant literature has been using the search engine with a reference to the last 10 years. The search string was “Building near/0 Design near/1 management”. The databases were AB/Inform (AB), Web of Science (WoS) and Scopus (Sco). The first search presented 289/6/192(AB/WoS/Sco) articles in the different bases and these were then reduced to 60/6/69 after discarding commercials and irrelevant journals (e.g. medical, chemistry etc.). Then the results were skimmed by reading the abstracts, keywords and titles, discarding those who were irrelevant. The review paper of Svalestuen et al. (2014) gives a good insight of the substantial amount of work done in the IGLC community concerning building design management, and this was added as well.

3. Results of the literature review

3.1. The building design process

In order to try to understand the difficulties of design management it is also important to understand the process in building design. The design process is often divided in several stages or phases. An example is the RIBA plan of work which has divided the construction process into the seven stages where stages 1 through 4 include design work (RIBA, 2013). The flow of information, focus points, planning and managing differ in these stages. A simplified definition is to say that design management is about managing people and information (Emmitt & Ruikar, 2013). People in this context are stakeholders in a building project and information being deliverables among stakeholders.

The final part of deliverables as drawings, models etc. are concrete and easier to manage than for instance ideas or evolving concepts from the creative minds of designers. “Design management is a complex social situation as value can be a socially constructed phenomenon and decision making to that end can be inherently unpredictable”(Kestle & London, 2002).

Brief stages and the implication that these can have on a project are attracting an increased focus hence they give inputs to the rest of a building process (Blyth & Worthington, 2001; El. Reifi et al., 2013; Gilbertson, 2006; Tilley, 2005). But this is an important and under researched area. The briefing period is also a complex stage to manage. If the management of the briefing phase is poorly conducted, it is likely that opportunities are missed out later in the design process (Tilley, 2005). On the other hand, Azlan-Shah and Cheong-Peng (2013) argue that good designers can improve the clients brief.

A briefing stage usually ends up in briefing documents, on which a project is based. In some projects, this process is short and very often only consists of a client and an architect. In this stage, the vast majorities of key decisions are made. Gilbertson (2006) argues that design cost is 20% of construction costs, yet maintenance and building operating costs are five times of construction costs and business operating costs can be as much a 200 times the construction costs. The research of El. Reifi and Emmitt (2013) revealed that the issues related to the design brief were responsible for almost 30% of the rework. Accordingly, they also discovered that the client brief was the largest hindering of the design value by over 60%. This highlights the importance of the briefing stage.

In the early stages of the design phase, such as preparation, brief, concept design etc., processes are creative, iterative and innovative. These are processes which many solutions, thoughts and ideas are shared between stakeholders. These processes need to be open and to enable the best solution to arrive (Hansen & Olsson, 2011). The process has an iterative form (Kalsaas & Sacks, 2011) and each iteration will hopefully contribute to the end value of a project.

Lawson (1997) defines design problems and design solutions as interdependent. Design problems cannot be comprehensively stated and there are no optimal solutions to design problems, and design solutions are unlimited in number. Thus, there is a need to control the design process, but also a major challenge. The design process can therefore be viewed as an endless reciprocal process versus the building production process is traditionally viewed as a strictly sequential process.

Bølviken et al. (2010) introduces the work of Thompson (1967) to describe the different processes of design and their interdependences. There are pooled interdependence, sequential interdependence and reciprocal interdependence. Bell and Kozolowski (2002) introduced a fourth dimension called intensive interdependence. Processes emerge at different times and at the same time in the design phase. This also needs a form for coordination, which is described as coordination by standardisation, by plan and by mutual adjustment. “Design decision making is often negotiated amongst groups and teams, it is an iterative process” (Kestle & London, 2002). This was followed up by Kalsaas and Sacks (2011) and Andersen (2011) who used the same concept in the case study to explain the design process of a hospital project.

Kalsaas and Sacks (2011) argue that it is important to understand dependencies in the design process in order to handle them. Andersen (2011) describes the coordination as negotiations, mutual adjustment and opinion based communication. Relations in a process follow different logics. One of the logics describes an “everlasting movement”, where everything is connected to each other (see Fig. 1). To be able to proceed, you must make a decision, regarding an element or structure, if not the process stops or it will not start. A concrete decision of a solution might then start a sequential process, yet a decision turning down a solution, might just set of a new reciprocal process. A second logic is to pursue decisions so that they again set of a chain of solutions and new decisions. Knotten et al. (2014) introduce the term reflective logic and sequential logic describing the logics of design process. The sequential logic is based on a sequential, linear, closed process. Activity A must be finished before activity B can start. These are the typical processes displayed in a Gant schedule, and they can be planed and managed by the management planning tools (Pinto, 2013; PMI, 2013).

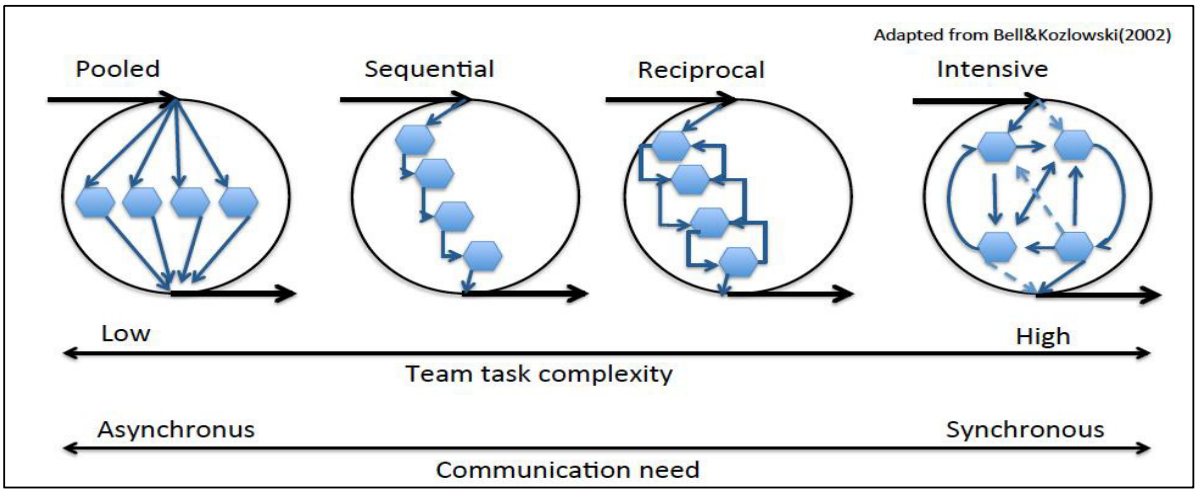

Fig. 1. Team task complexity.

The reflective logic is dealing with reciprocal, iterative and intensive processes. Activity A needs input from activity B, before it can finish, yet activity B needs input from A before it can deliver its output to A. The design phase typically starts with a high amount of interdependencies and team task complexity as a design team is looking for the best solutions. As design problems are solved, interdependencies are team task complexity are reduced and consist of singular tasks (e.g. drawing completion). In turn, Alvesson and Sköldberg (2009) describe reflective research to consist of two characteristics, i.e. careful interpretation and reflection. This is coherent with Lawson's (1997) description of the process as analysis, synthesis and evaluation. Therein, a logic looks at a problem, tries to generate a solution and then evaluate the solution, before this might lead to a final solution.

3.2. Managing the building design

A typical approach to project management is to gain control of a process in regard of time-cost-quality (Eynon & Building, 2013). In sequential planned processes, it is possible to see if an agreed drawing is delivered at the right time and how many hours were spent. Quality can be more challenging. This approach enables you to secure the scope of a design team but this may not necessarily deliver the most optimum value for a client. This is in line with many arguments for the importance of design in making value for a project (El. Reifi & Emmitt, 2013; Emmitt et al., 2005; Thyssen et al., 2008; Gilbertson, 2006). Value and waste are important for both the project as a whole and its design process. Likewise, processes and decisions are important vis-à-vis creating value (Koskela et al., 2013).

If the building design process consists of pooled, sequential, reciprocal and intensive processes, the managing of the process is complicated. A standard project management approach (Pinto, 2013; PMI, 2013) can help you manage pooled and intensive processes, but it is not an effective tool to manage a reciprocal or an intensive process. Mintzberg (1983) describes processes with reciprocal and intensive interdependencies as adhocracy. Adhocracy consists of a highly organic structure with little formalisation of behaviour, high job specialisation based on formal training and specialists in functional groups, i.e. a multidisciplinary design team. Managing involves chaos and unpredictability. The organisation of projects by hiring different consultants makes it relevant to compare challenges to design organizations with virtual teams (Bell and Kozolowski, 2002). Project culture, clear responsibilities, real time information and transparency become increasingly important as complexity increases in projects. Morgan (2006) suggests that we rethink the way we organize when we are at the edge of chaos. “Managers need to flow with the change rather than try to predesign and control in a traditional way.”

From the management perspective, the planning and the execution of plans have been debated. Many have agreed upon that design phases are not directly comparable with construction phases and, hence, you cannot use the same management tools (Bølviken et al., 2010; El. Reifi & Emmitt, 2013; Hansen & Olsson, 2011). The Lean Construction approach of using Last Planner as a principle of planning in building design management has been debated, too. Hamzeh et al. (2009) and Rosas (2013) argue for the use of Last planner. Hamzeh et al. (2009) report on the use of Last Planner at the Cathedral Hill Hospital (CHH) project and argue for a fact that "collaborative planning and continuous re-planning were the major constituents of the planning process at CHH during design where the iterations were ubiquitous, the tasks were complex and interdependent, and the constraints need to be removed in time for task execution". Thus, the planning of complex building designs processes is continuous process and it can in some extent be used for planning and executing design work. Hansen and Olsson (2011) argue for a layered process, where the Level of Detail (LOD) in the planning should be adapted to different needs for information in projects. Bølviken et al. (2010) criticise the shortcomings of the Last Planner method used in design. An approach to use LPS in design is the Collaborative Design Management (CDM). CDM looks at planning, teambuilding, coordinating (meeting) and constraints. The case study by Fundli and Drevland (2014) says " ...CDM enables positive changes in the design process compared to more traditional approaches". There has also been some attempts to automate planning processes. Rosas (2013) tries to integrate the Design Structure matrix and Last Planner in building design. Senescu et al. (2014) introduce a Design Process Communication Methodology. Cheng et al. (2013) argue for modelling resource management in building design process.

Interaction among design participants is important. The main purpose in a design phase is the exchange of information and the transformation of information to ideas and solutions to be presented to others. This exchange process is difficult to plan and follow up, and equally difficult to foresee interdependencies that each exchange might have. Azlan-Shah and Cheong-Peng (2013) argue that "coordination needs to be performed by a designer".

The way we communicate is therefore important. Otter and Emmitt (2008) describe the two ways of communicating, i.e. asynchronous and synchronous. Synchronous communication is described as an information flow between two or more directly using hearing, sight and talking (e.g. meetings, telephone etc.). Asynchronous communication is a remote flow of information, which is not directly in time (e.g. emails, drawings, models). The more complex processes are, the higher need is for synchronous communication. Flager et al. (2009) have shown that as much as 58% of the time is spent in managing the information in the design phase. With a more effective information management, some of this time can be reduced and used in more value creating activities.

Synchronous communication is an efficient design tool. This is supported by the approaches of Concurrent Engineering (CE) and Integrated Concurrent Engineering (ICE). The use of extreme collaboration by NASA (Mark, 2001) created a possibility for faster and more high quality design in the building industry (Chachere et al., 2004). When you are trying to manage a reciprocal or incentive process, ICE is a powerful tool. It needs a commitment among key stakeholders in order to make necessary decisions to keep a design process evolving and it works well with adhocracy.

The use of Building Information Model (BIM) in the construction industry is increasing and this is a powerful tool for asynchronous communication but also as a tool to use in synchronous communication as ICE. Moum (2008) has described the use of collaborative design and the participants' reflection of how a BIM could ease the difficulties to understand the complex problems and solutions. The benefits of communication is good (Clemente & Cachadinha, 2013) and possibilities to increase quality by an early clash detection can save much money in projects (Khanzoode et al., 2008).

In order to properly manage a design process, it is important to set up the metrics of processes. Drucker (2008) argues for the importance of measuring work in organisations and he elaborates that you need "controls" (different measurements) in order to get control of a process.

Kristensen (2013) identifies 14 key performance indicators (KPI) that are needed to control design processes. These KPIs are classified as the strategic, tactical and operational metrics. In addition to time-cost-quality, this metrics includes e.g. requests for information, participation and proofing. The need for metrics to improve design processes is also debated (Carvalho et al., 2008; Leong & Tilley, 2008; Succar et al., 2012). Even if it is important to measure the project outcome of time and cost, it is also important to set up metrics controlling the quality of design

and the exchange of information. Using metrics to follow up the quality and efficiency, e.g. in ICE sessions, is important in order to improve design process (Knotten & Svalestuen, 2014).

Keeping the value perspective in mind, new ways of managing the earliest stages of the building design process might be considered. A comparison towards innovation and product design gives alternatives to conduct building design development, e.g. the Innovation Diamond (Darsø, 2011) and IDEO (Best, 2006)).

4. Discussion

Planning, coordinating, executing and controlling might be key tools of project management. As presented in this paper, it is not as straightforward for building design management. The understanding of the nature of processes is necessary to manage building design. The nature of processes is complex and consists of many types of interdependencies that need to be addressed differently in design phases. Allowing iterative processes to run as long as necessary can be beneficial to the value of a project, but if they run too long they can have serious implications on a project, concerning time and cost.

Acknowledging the fact how the logics influences the design process is the first step to improve the way we manage the process. The feeling of "chaos " or "ad-hocrazy" can somehow be reduced by planning, using CDM, but also the use of SCRUM can give benefits (Lia et al., 2014). SCRUM is adapted from the Software developers. It consists of small teams working with specifics tasks or problems in order to solve them within a short concrete time limit.

The efforts of Virtual Design and Construction (VDC) and the technics of the Last Planner seem to be the most current approaches to deal with building design management. "The VDC project model emphasises those aspects of the project that can be designed and managed, i.e., a product (typically a building or plant), an organisation to define, design, construct and operate it as well as a process that organisation teams follow" (Kunz & Fischer, 2009). VDC that focuses on using BIM as a tool of communication as well as ICE sessions as a tool to create agreements and solutions are both applicable for design processes with a sequential and reflective logic. Even if there is no consensus that the Last Planner is an adequate tool for planning building design processes, Hamzeh et al. (2009) have showed that the potential of the method in the planning and re-planning of tasks. This together with the measurement of a process and products enables a design manager to follow up the building design phase.

5. Conclusion

Even if there is much more research to be done concerning building design management, the last years have witnessed some new research and efforts in order to improve building design methods. This paper reports on the different interdependencies that occur in the design phase and how to coordinate them. The interdependencies vary throughout the design phase and sometimes the design phase consists of all the four types. It is important for a design manager to be aware of this, so the use of management tools can be managed properly. Even if new building design management approaches can be used for all dependencies, using the same approach to handle both reflective and sequential dependencies might be contra productive. By identifying which processes are sequential (and can be planned in detail) and which processes are reciprocal or intensive (and cannot be planned in detail), a design manager can prioritise and free a focus on the effective process. Hopefully, this paper gives some new insights to design managers and stimulates to further academic research in the field of building design management.

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