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CASE STUDY ON DESIGN MANAGEMENT: INEFFICIENCIES AND POSSIBLE REMEDIES

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ABSTRACT

Delivering better products with a reduced lead time and less resources has become the primary focus of design management. The aim of this work is to revisit typical design management inefficiencies and discuss possible remedies for these problems. To this end, a case study and interviews with seven Estonian architects were carried out. The data obtained was analyzed within the framework of the transformation-flow-value theory of production. Despite its failure to deliver customer value, a single-minded transformation view of operations has been the dominant approach taken in design management and processes, leading to inefficiencies in design practices.

KEYWORDS

Design management, design inefficiencies, TFV conceptualization.

INTRODUCTION

The delivery of better value to the client with a reduced lead time and less resources has become the primary focus of design management (Morgan and Liker, 2006). The dominant approach to design management and processes has been a single-minded transformation view of operations (Ballard and Koskela, 1998), leading to anomalies in design practices, such as large batches of work and/or rework waiting for information, poor specification of client needs and requirements, and poor generation and management of quality.

In this study, we revisit typical design management problems, in other words, waste, in the designing of buildings. To help illustrate current design management inefficiencies and processes, a case study involving an Estonian full-service design company was carried out, and interviews were conducted with seven architects.

In the first part of this paper, a theoretical framework for analyzing design practices is outlined; in the second part, the results of the case study and interviews are summarized; and finally, inefficiencies and possible remedies for the root problems are analyzed and discussed based on the transformation-flow-value (TFV) conceptualization of production (Koskela, 2000).

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NATURE OF DESIGN AND DESIGN MANAGEMENT

Design and engineering sciences have their origins in craftsmanship (Jones, 1992), which Aristotle classified as the practical knowledge of making, *techne* (Channell, 2009). In the early years of engineering sciences, the focus was on designing artefacts by applying the scientific laws and theories (Rankine, 1872). The 20th century saw the emergence of a design methodology, with a focus on the application of systematic scientific practices to engineering and design. Design science, popularized by Simon (1981), is a relatively new field studying design and design inquiry. One of the key ideas of design science was that design inquiry begins with the needs of the client. Thus, the main function of design inquiry is value generation for the client, and construction is the realization of a proposed solution with the lowest possible loss in value.

Since the 1960s, the development of design methodologies has been channelled by philosophical pluralism (Buchanan, 2009), which has shaped the inquiry of related subject matters, methods of thought and action, and the guiding principles of design. In his historical review, Buchanan (2009) distinguished three major strategies for inquiry: Dialectic, Design Inquiry (Rhetorical Inquiry and Productive Science), and Design Science. The origins of these strategies can be traced back to the ancient Greeks, whether theoretical and formal or practical and pragmatic. What distinguishes these different strategies is how the judgment of good or bad design is reached.

In the present work, the focus is on design inquiry, on both the act of designing and design as argumentation. More specifically, the TFV theory of operations management is used to study current design practices. Koskela has argued that the three different views must be seen as different dimensions of the same design task, as shown in Figure 1, and this is the reason why this theory is used as the basis for studying design management inefficiencies.

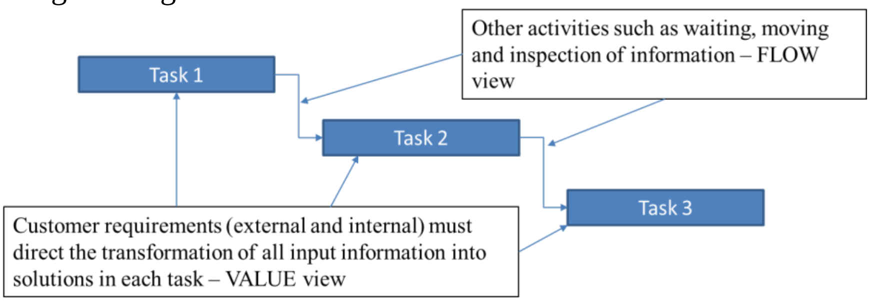

Figure 1. Simplified view of TFV conceptualization of design processes and tasks (Koskela, 2000).

The reductionist approach, called the transformation view, is guided by the principle of decomposition. The aim is to hierarchically break down the design tasks to optimize and control design task attributes, thus, focusing on control and risk reduction (Alberts and Hayes, 2003). The flow view is a practical and pragmatic process-oriented view, focusing on a timely sequencing of tasks and their interdependencies to optimize the design flow as a whole. According to the value view, which is driven by the customer-supplier relationship, customer requirements (external and internal) must direct the transformation of all input information into solutions for each task. Flow addresses the time-dependent complexity (tasks must be completed in the right sequence), and value generation addresses the time-independent complexity (Pennanen and Koskela, 2005).

The meaning of value is very broad and complex (Bertelsen and Emmitt, 2005), giving rise to a “wicked problem”, as stated by Rittel and Webber (1973). Design problems can be wicked due to the instability of problem definition and the qualitative nature of value judgment in combination with quantitative objectives; for example, the client may prefer a product, which is not analytically the optimal solution. Additionally, design in the early stages of a process is inductive, and more than one solution exists to a particular problem (Pennanen and Koskela, 2005). Ballard and Koskela (2013) have argued that rhetorical methods could be used to derive the value judgments of a design solution.

METHODS

To understand current design management approaches and processes, a qualitative case study method is used to acquire context-dependent knowledge (Fellows and Liu, 2009). The lead author of this article observed and interviewed people in one of the leading design offices in Estonia. Seven Estonian architects were also interviewed to validate the observations made in the design office. This work focuses on the early stages of design and processes, including the pre-design (not explicitly but as implied by the consideration of the needs and requirements of clients), schematic design and preliminary design stages.

CASE STUDY AND INTERVIEWS: CURRENT DESIGN PRACTICES

OVERVIEW OF DESIGN OFFICE AND PROJECT MANAGEMENT ACTIVITIES

The design office in this study has the traditional hierarchical organizational structure, where designers and engineers work within their dedicated units. Work within a design unit is not centrally coordinated or organized but is the responsibility of the functional unit manager. In some units, work is highly specialized and standardized, in others, not: for example, in the architectural unit, one architect does everything within a project from beginning to an end, while in the structural unit, there are hierarchical levels of responsibility and specialization (the head of the unit, the head structural engineer, and three levels of technicians).

The design office has an ISO (International Standardization Organization) Certified Management System (CMS), which describes general business and project management processes. The “main processes”, constituting only a small share of the whole set of processes, are design processes, which are the services they are selling to their customers and where value is created.

The design office has not specialized in any particular area. Project managers are not typically involved in the sales and marketing of the company’s services. The architect, structural and building services engineer, and electrical engineer are involved only insofar as they provide an estimate of the resources (time) required to deliver a project. The final decision on pricing and estimates is made by a sales and marketing specialist, who also happens to be one of the owners of the company. Typically, under client pressure, project estimates must be reduced to win the contract, introducing uncertainty into the design. There is even more uncertainty when the office undertakes a project in an area in which it has no previous experience. According to the structural and building services engineer, these projects often cause many problems. Additionally, the architect and engineers feel that when they are responsible for only part of a design, there are also more problems than if the whole design were being done in-house.

In the CMS, design management is called project management. The description covers only those stages following the finalizing of the contract with the client. Project management is divided into phases with certain repetitive activities. The design project management model typically describes project evolution from the perspective of the company/design office, and the focus is on the outputs of each stage. This means that the project manager is expected to deliver a certain set of project documentation at the end of each phase. In the CMS, they do not further elucidate the design and engineering processes, phases, and activities, i.e., where the actual design takes place. The project manager does not usually interfere with the actual design process. The focus in project management is on planning and control. The latter means that the project manager prepares plans and during weekly project meetings makes certain that the designers are keeping to them.

Project stages and phases within the main processes are differentiated in terms of content and the level of detail of the documents produced, each of which are an attempt to get commitments to a progressively more detailed design in hopes of preventing backtracking. The content of design documentation at different stages has been standardized by the local “Building Design” standard (ECS, 2012), which, however, only stipulates the topics to be covered and not the actual content. The architect and engineers believe that the content of building information models (model element content and the level of detail) and quality could be more completely standardized.

MANAGEMENT OF MAIN PROCESSES

The description of the main design processes is based on observations made in the design office and interviews with all key staff, including the managing director and board member/sales representative/co-owner.

After the contract is signed, the project manager prepares the project schedule for the design work. Tasks in these plans are generic, simplified, and sequential and/or concurrent. Design progress is monitored at the weekly work planning meetings with the managing director, project managers and unit managers. Currently, there are no other systematic mechanisms in place for status reporting or progress monitoring, except in the case of the structural engineering unit. The head of the structural unit has implemented a cloud-based application called Todoist to create, assign, and monitor the daily activities of the structural engineer and technicians.

Work within the units is usually conducted in relatively large batches and iterations are avoided, as these are recognized as an inefficiency. As to the reduction of interdependencies in the design work, the architect and engineers have learned from experience what major problems may arise and have incorporated assumptions in designs to obviate late design changes. This approach seems to work relatively well, as the design team in this design office has worked together for many years and has learned to avoid certain problems. In the architect’s own words: “Over the years, we as a team have learned to avoid problems, as we have gained a better understanding of what the other units need or require from each other, and therefore, we can consider these in our designs!" Thus, according to the architect and engineers, the main reason for late changes is client behaviour.

ORGANIZATION OF DESIGN OPERATIONS

This section is based on two sources, observations and interviews carried out in the design office and interviews with seven Estonian architects, who have varied understandings of the architectural design process. One of the seven interviewed architects sees it as something unique to a particular project. The others believe that there is a common process, while what differs is the creative part of the work, which according to them, cannot be standardized.

The architects see the early design stages as their primary field of work. They work with the client and develop a design solution. Typically, at the beginning of a project some meetings are held to determine client needs and requirements, and then the architect works quickly to synthesize this information and come up with a design solution(s). Determination of the specification does not involve a very deep analysis of client requirements, and they are not broken down into functional requirements, rather the goal of the architect is to understand the design space and its boundary conditions in a broader sense. He/she usually begins with several concepts and then selects one to develop in greater detail. Only after the solution has taken more concrete form, does he/she go back to the client to have the solution approved. Usually, several iterations are required to come up with a satisfying solution.

Engineering specialists are not usually involved in schematic design. The architect may, however, consult with engineers on various aspects, such as structural scheme or space requirements for building services. Thus, the architect usually develops a conceptual design in isolation and principally with regard to functional space requirements and aesthetics. The structural engineer and building services engineer enter into the design process more systematically at the preliminary design stage. According to the structural and building services engineers, the design space is typically fixed for them, and they must then work with what they have. Since engineers may or may not be able to engineer a solution as the architect has conceived it (for example, when structural spans are too wide), negative iterations are sometimes needed at this stage.

Based on several interviews with architects and engineers, a typical design process, with design phases and activities, is shown in Table 1. The phases follow the chronological order of the design process and are conducted essentially in those batches. Intermediate coordination of the design disciplines is handled by the architects and engineers themselves.

ANALYSIS OF INEFFICIENCIES AND POSSIBLE REMEDIES

In this section we provide a summary of the design process and management related inefficiencies. We also look at possible reasons for the latter and propose possible measures for overcoming them. The testing of these ideas will be left to future research.

ORGANIZATION INEFFICIENCIES

Variability in projects

The observed design office works primarily on apartment, office and warehouse buildings, but it also often takes on atypical projects, introducing uncertainty: limited knowledge and experience in the design processes for a particular building type result in poor anticipation of possible problems, and the high learning curves demanded to develop technical alternatives and solutions lead to an overutilization of resources. Thus, atypical design projects lead to uneven demands (*mura*) and the overtaxing of resources (*muri*), resulting in process-related waste (*muda*) (Morgan and Liker, 2006). This is not to say that the design office should decline such projects, but rather that appropriate measures should be taken to manage them. The Last Planner System (Ballard, 2000a) and Agile design sprints (Sutherland, 2014) can be used to integrate and align the design production effort and to embrace possible variability.

DESIGN MANAGEMENT INEFFICIENCIES

Design as project management and its dual nature

Current design management methodology is based on project management techniques (the transformation view) developed in the 1950s and 1960s (Koskela, et al., 2014b). This highly idealistic management approach has caused anomalies in design production. Clark (1991) has reported the following problems in conventional design: difficulty in designing for simplicity and product reliability, excessive development times, weak design for constructability, inadequate attention given to clients (the specification of client needs and requirements is not recognized as adding value), weak links with suppliers (design subcontractors), and neglect of continuous improvement.

These failures are caused in part by neglect of the views of flow and value (Koskela, 2007). Due to the dominant role of the transformation view in design management, tasks are managed and optimized (in terms of duration and resources) in isolation and thus, the flow and value generation aspects of the design tasks are left for informal consideration by designers. If design is seen as a flow, there are four states of information (Koskela, 2000): transformation, waiting, moving and inspection. During the inspection phase, tasks are being checked to see how they conform and contribute to overall customer value; in the design context, this means design verification and validation (also known as evaluation).

Currently, only value-adding activities are systematically considered, and other activities, which do not directly add value, but cannot be eliminated, are not explicitly managed. This is evident when observing a typical schedule in the design office: only design validation is included in the project master plan, at the end of the typical design life-cycle.

Therefore, design management and organization have a dual nature, as these two are separate (Koskela, et al., 2014b). There are virtually two layers of organization, one focusing on planning and controlling, and the other, on getting the job done. The Last Planner System improves design production by integrating different planning and control solutions into a cohesive whole (Ballard, 2000a).

Table 1. Overall design process: stages, phases and activities

Design Stage	**Design Phase**	**Design tasks**	**Responsible person**
Schematic Design	Defining initial task	1. Collecting project information (surveys, geology, dendrology, site conditions, urban zoning requirements, etc.) 2. Defining initial task and design requirements (meeting or meetings with client) 3. Compiling design specification and confirming it with client 4. Exchanging initial ideas and discussing architectural design parameters	Architect
	Iterative development of design alternatives	**Spatial design and layout** 5. Generating ideas within and outside of the constraint space (the latter required for understanding other possibilities) – thinking and sketching go hand in hand (outside-in approach) 6. Testing ideas with BIM (inside-out) to ensure that spatial requirements are being met 7. Consulting with building services engineer regarding spatial requirements of technical rooms and shafts **Conceptual selection of façade solutions and internal structures** 8. Selection of element types and finishing materials (external and internal walls, roof, window, floors and shading) 9. General dimensioning of building elements 10. Iterating design alternatives with client (usually point-based approach)	Mainly the architect
	Finalizing the selected alternative	11. Further development of selected alternative 12. Modelling and visualizing selected solution 13. Agreeing on final schematic design solution with client	Architect
Preliminary design	Dimensioning and detailing of architectural solutions and preparing headnote	14. Consulting with structural engineer regarding conceptual structural schema and general dimensions of load bearing elements/layers 15. More accurate dimensioning of building elements and their components/layers (external and internal walls, roof, window, floors and shading) 16. Detailing of important building joints (e.g., parapet) 17. Agreeing with client on technical solutions	Architect
	Preparing a headnote for structural solutions	18. Specifying normative loads and live loads 19. Specifying conceptual structural schema and structural elements 20. Agreeing with client on technical solutions 21. Preparing headnote for structural project	Structural engineer
	Specifying utility solutions	22. Selecting solutions for connecting building with external utilities 23. Confirming designed solutions with utility owners 24. Agreeing with client on technical solutions	Building services engineer

	Preparing a headnote for building services	25. Specifying loads and requirements 26. Selection of energy supply type (including renewable energy) 27. Selection of distribution systems and end elements (diffusors) 28. Agreeing with client on technical solutions 29. Preparing headnote for building services	Building services and electrical engineers
	Energy certification calculations	30. Specifying energy related solutions 31. Specifying the thermal properties of elements for energy simulations 32. Calculations for energy certification	Building services engineer
	Building permit and hand-over to the client	33. Preparation of project documentation 34. Application for building permit 35. Handing project over to the client	Project manager or architect

Poor planning and avoidance of iterations

Typically, project managers prepare the project schedule, taking a top-down approach, where plans are developed first and then pushed down through the organizational hierarchy to the designers doing the actual design work. Schedules are prepared using two dependency types: sequential and concurrent (Eppinger, 1991). A third type of connection is an iteration (Lawson, 1980; Ballard, 2000b); two tasks are intertwined and mutually dependent on each other.

To reduce interactions and iterations, designers and engineers have incorporated assumptions into the design that safeguard against late design changes – negative iterations (Ballard, 2000b; Koskela, 2007). The longer the negative iteration is in the chain of interdependent tasks, the more rework it results in. These assumptions lead to over-designed artefacts with large buffers in solutions, causing contractors to optimize costs before or during construction.

Poor planning and simplistic scheduling have also resulted in the inability to monitor and systematically control design progress. When interviewing design office personnel, we found that the only monitoring process in place was the weekly project coordination meeting, organized to keep the company's executives up-to-date on project progression and solve important managerial issues. This has been causing poor or over-utilization of resources, as designers feel that their workload is fluctuating very widely.

The Last Planner System (Ballard, 2000a) and Agile methods (Sutherland, 2014) could be used together with BIM technologies to streamline the management and organization of design production, for establishing and aligning design and information flows to deliver client value continuously.

DESIGN ORGANIZATION INEFFICIENCIES

Poor specification of client needs and requirements

In the early design phases, the architect is primarily working with the client and developing a design solution. Usually, some meetings are organized to specify the client design space, but there is no clear specification of client requirements or control parameters, rather he/she typically hurries to synthesize the design (Ballard and Koskela, 1998). He/she is more interested in the spatial and functional design of the building, while other design criteria, such as cost, sustainability, energy efficiency, constructability, etc., are not considered explicitly but rather heuristically.

The current architectural design process suggests that the architect starts designing a particular type of building with some conceptualization already in mind, as stated by Lawson (1980); e.g., a general conceptualization of an office building and its spatial layout already exist, while the subject of the meetings for the architect is to identify and specify the boundary conditions. This design method has been considered a point-based method, where a designer after considering several alternatives, jumps to an idea (proposes a hypothesis), which he/she then starts to optimize through iterations with the client (Sobek, Ward, and Liker, 1999). In the philosophy of science, this approach is known as the hypothetico-deductive method of scientific inquiry (Losee, 2001).

Analysis of contextual aspects and client needs and requirements is necessary to move progressively through the induction process to design conceptualization, accepting that generic problem statements can be produced by considering the actual context and client problem (Koskela, et al., 2014a). Integrative design (Reed, 2009) and integrated design begin with the specification of client needs, requirements and project context in four domains (habitat, water, energy, and materials). The voice of the customer, quality function deployment, systematic workspace planning, and key performance indicators have been used to systematize the analysis and break down client needs and requirements, which can then be systematically pushed through the whole design process (Koskela, 2000).

Poor integration of design disciplines and decisions in the early design stages

Architects make design decisions on the basis of the function, image, and aesthetics of the object, letting them become fixed solutions, without fully realizing how these decisions impact building performance and other engineering aspects. Problem solving is pushed downstream with the belief that appropriate engineered systems can be developed.

The aim should be to push problem solving more upstream, as this would help to identify potential problems earlier, making it easier to make changes. Methods such as front-loading, set-based design, upstream problem solving, and concurrent engineering (not in terms of time reduction, but how it takes life-cycle into account) can be used within these methodologies. These approaches break up the long communication chains, and through collocation, information sharing, communication on design alternatives is instantaneous.

CONCLUSIONS

Based on the case study observations in the design office and interviews with architects, it is clear that many anomalies have been introduced into the system due to poor design management. Currently, the conceptual model for managing and organizing design is based on the transformation view of operations, with a focus on the planning and controlling of design production. The other views, flow and value, are decided informally by the designers. The focus on transformation activities, i.e., value adding activities, has led to inefficiencies: poor conceptualization of variability in projects, a virtual gap between management and production, poor planning and control, poor specification of client needs and requirements, and poor integration of processes and people. Many already existing and evolving concepts, methodologies and methods can be applied to reduce these inefficiencies. There is a need to view design paradigmatically taking into account all views: transformation, flow, and value.

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