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Conceptualizing Design Management for Construction Projects
Bridging the Gaps between Urban Planning, Architectural, and Engineering Design

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Abstract: The aim of this discussion paper is to propose an inclusive definition of design management for the construction industry. This definition is based on reducing the separation between several fields of activity that have, to date, mostly been elaborated independently. These fields of activity can be broadly grouped into the phase-based and disciplinary design conceptualizations. The differences between the conceptualizations are mainly a result of domain-dependent approaches to the design problem in construction. Based on these differences, construction projects form their design supply chains and delivery methods. Urban planning and architectural design, for example, strongly implement criteria of aesthetic and social value into their processes, whilst focusing less on technical aspects of the project. In such a constellation engineering design can be considered as a commodity in the process. In this traditional representation, engineering is embedded into the architecture of the facility and, respectively, architecture is embedded into the urban planning of the area. Instead of traditionally emphasizing the differences between different planning tasks, this discussion argues for a common representation of design operations in the construction sector. This representation defines design as a group of tasks that share characteristics of the planning problem. Preliminary conclusions of this theoretical discussion suggest that the design process can be grouped into its conceptual and detailing components. In this vein, each discipline reaches the concept solution in a different time-frame and subsequently elaborates the concept solution. In conclusion, this discussion proposes that the flow of design should not be divided in terms of disciplinary and phase-based boundaries, but in terms of conceptual solutions and detailing of each of its constituent parts. The implications of this discussion can be generalized at the level of both construction project management, as well as public policy development.

Keywords: Design management, Planning problem, Construction project management, Interdisciplinary processes.

1. INTRODUCTION

"Engineering, medicine, business, architecture and painting are concerned not with the necessary but with the contingent - not with how things are but with how they might be - in short, with design." (Simon 1996)

Most artefacts and other achievements that the human kind is collectively proud of are a result of long and laborious mental work, also known as *design*. Although the invention of wheel and fire may have happened as a sudden "spur of the moment" without any previous planning, this is definitely not the case with achievements that are embodied in complex artefacts such as the automobile or the skyscraper. This is not any different for a construction project. Any facility needs to exist in an artificial form before it can exist in the physical form. Although this form of existence is not tangible, it is still as realistic as the physical existence in the form of, say, concrete, asphalt, bricks, and steel. This artificial form of existence belongs to the realm of planning and design and the aim of this paper is to discuss these terms in the context of the built environment.

A construction project results in a new product with many different levels of content. From the inside shell of the project, and, without going into a detailed disciplinary elaboration, those levels of content would be the project's overall spatial layout, architecture, engineering, and construction. Every construction project is, by definition, also embedded into its external context that consists of the environmental, economic, and societal systems. Currently, different domain-dependent conceptualizations determine what is here meant with under the term *design.* How, then, to integrate this seemingly omnipresent decision making process that overarches every imaginable aspect of the construction project? As in any planning process, the designs will most likely never be embodied to their full extent, but the decision making process that underlies the designs is, nonetheless, indispensible. Overall, as the complexity and size of projects is increasing, the design industry becomes increasingly fragmented as markets become increasingly saturated with highly specialized firms. Furthermore, what used to be considered the realm of designer's authority, now oftentimes falls under the auspices of the project manager. In order for this situation to be improved, the design process calls for its reintegration under the leadership of designers who, on the way, need to also assume the role of project managers (see, for instance, Gray and Hughes 2001).

As the following sections will demonstrate, however, organizing the decision making process across different levels of content is something that needs to be addressed more deeply than what the current state of knowledge provides insight into. This discussion will attempt to achieve a small step in charting the path towards an integrated domain-independent definition of design in the built environment.

2. TRADITIONAL AND EMERGING PARADIGMS

The dominant paradigms of design in the built environment have been fragmented along the disciplinary boundaries. Urban planners, for instance, share an ontological understanding of design that is substantially different from both what architects and, even more so, engineers conceptualize. This has been common practice since the split of architecture and engineering professions and has been widely acknowledged in literature (e.g., Vermaas and Kroes 2007). In this traditional paradigm, urban planning and architectural design are defined as planning activities with a broad impact on not just physical world as we know it, but also on the society that comprises it. On the other hand, the same paradigm reduces engineering to a technical support role, outside the realm of creative design. This is also evident in terminology that clearly distinguishes the two concepts in the widely-used term of *design and engineering*.

Vermaas and Kroes (2007) illustrate this situation as "*engineers make things that work and architects order space, giving visual expression to the built environment.*" Moreover, "*architecture is perceived to be similar to the fine arts. Building owners may seek to enhance their own social position through association with the artistic authority of the architect.*" On the other hand, *"engineering is an objective science applied to specific problems"* is an interpretation which makes the disciplinary boundary of the design and engineering seem logical.

How justified, however, is the dominant paradigm that differentiates between the fields of design and engineering in the built environment so clearly? Table 1 below summarizes some features that distinguish designers from engineers within the traditional paradigm.

In this paradigm, designers are perceived more in terms of artistic creativity, while engineers are in their mental programs more aligned with hard-sciences approach. Indeed, as Cross (1982) points out, mental models are significantly different between design and scientific thinking:

"The designer is constrained to produce a practicable result within a specific time limit, whereas the scientist and scholar are both able, and often required, to suspend their judgements and decisions until more is known--'further research is needed' is always a justifiable conclusion for them."

Table 1 – Differences between design and engineering

	Design	Engineering
Type of systems dealt with	Socio-technical, ill-structured, non-linear, dynamic	Technical, structured, linear, static
Problem formulation	Wicked problem	Tame problem
Mental model	Creative, artistic expression	Application of scientific principles
Solution domain	Infinite	Bounded
Authorship	Individuals are acknowledged	Collective, non-recognizable
Organization structure	Flat	Bureaucratic

Although this conclusion is hardly debateable, it also clarifies that the list of claims from Table 1 is based on an implicit assumption that designers are artists and engineers are hard-core scientists. Indeed, a claim that is in many cases far from reality. The next question that arises is how to sort out the terminological confusion that arises from terms as, for instance, *engineering design* or *design science?* On the one hand, engineering implies a scientific mental model based on analysis, whereas design implies the constructive and creative mental model based on synthesis. The answer to this question is to abandon the traditional disciplinary concept of design and engineering and begin using a more inclusive definition of design.

To improve this situation, scholars have coined various conceptualizations for design activities in the context of the built environment. This formed a consistent research stream of architectural management (see, for example, Emmitt et al. 2009). Within this research stream, communication is identified as the core substance in the (architectural) design process. Researchers focus on both more formal aspects of communication that is enabled by technology (den Otter and Prins 2002) and more informal collaborative aspects of multi-architect collaboration (Sebastian 2003). The second research stream attempted to map the interdisciplinary aspects of design, which resulted in a different body of literature that structures the design process across time, roles, and proposes practical methods for its management (Anumba and Evbuomwan 1997; Austin et al. 2001; Formoso et al. 2002; Yassine and Braha 2003).

The first research stream has advantages over the second one because, indeed, architects have traditionally been designers of the built environment and the profession most certainly embodies vast amounts of knowledge on the design process. However, the view in which architects are assumed to be natural leaders of the design process can also be considered a shortcoming in its own right. Although this leading role may still be true in a large number of projects, the increasing number of disciplines participating in even more projects necessitates decentralized leadership of the design process (Gray and Hughes 2001). This implies that, while the concept of design in terms of architectural value will never be lost, it needs to be complemented with design paradigms from other participating disciplines. The advantage of the second research stream is that it creates a practical toolbox that enables seamless management of the design activities. Similarly to the first research stream, this can, however, also be considered a shortcoming. Namely creating structures and processes is of limited value for a field of activity that is essentially ill-defined: design.

In conclusion, literature review reveals that an inclusive definition of design management is still missing for the built environment. As the next section will show, this definition should abandon the disciplinary constraints and move into the realm of conceptual theorizing and the nature of the design problem.

3. DESIGN AS A PLANNING PROBLEM

"Everybody designs sometimes, nobody designs always. Design is not the monopoly of those who call themselves "designers". From a downtown development scheme to an electronic circuit; from a tax law to a marketing strategy, from a plan for one's career to a shopping list for next Sunday's dinner, all of these are products of the activity called design." (Rittel 1987)

That said, it is reasonable to reconsider the purpose of the design process. Most certainly, it is to construct useful artefacts that will meet the needs of its users. At the front end of the design process is, therefore, a set of requirements, which should have been negotiated with the client previously. On the back end of the design is the construction process that will eventually turn the artefact into existence. The designer's position is in between the project requirements and the actual construction process. In spite of this intermediary position, the transitional phase of decision making that we call design has the power to determine the faith of the product. Dealing with the back end interface of the design process has proven as particularly problematic. It has led to the emergence of a new field, constructability, whose main goal is to align the design and construction processes so that the design is buildable. This corroborates the above-introduced claim that that not only "designers" have legitimacy to participate in the design process. On the contrary, a number of actors assume the role of designers as they influence project decisions. Therefore, design is essentially a planning problem that is:

- Socially negotiated: Design adheres to rules of social construction of reality where the knowledge is contingent upon the actors constructing it rather than any inherent quality that exists in its own right (e.g., Calhoun 2002).
- Highly interdependent: Parts of the design decision making process cannot exist in isolation, they are reciprocally interdependent in that one task cannot be altered without the need to alter all the other (Thompson 2003).
- Uncertain: Because information about the project is "under construction", there is an inherent lack of information that would be needed to reach a decision unambiguously (Galbraith 1974).
- Wicked: Wicked or ill-structured problems, as opposed to tame problems, are such that their complete formulation is not possible (e.g., Rittel 1977). All planning problems are essentially wicked problems which makes them inappropriate for traditional mathematical optimization methods.

Because of these characteristics, a cognitive approach from behavioural sciences is more appropriate than traditional scientific reasoning for studying and defining design management. Namely, although designing aims to be rational planning, the actual cognitive process is at the same time spontaneous and fraught with uncertainty. Therefore, planning by designing does not adhere to rules of optimizing and utility maximization and evidence for this can be found using introspection as the next section will show.

3.1 Behavioural Aspects and Retrospection

"Traditional economic theory postulates an "economic man," who, in the course of being "economic" is also "rational." This man is assumed to have knowledge of the relevant aspects of his environment which, if not absolutely complete, is at least impressively clear and voluminous. He is assumed also to have a well-organized and stable system of preferences, and a skill in computation that enables him to calculate, for the alternative courses of action that are available to him, which of these will permit him to reach the highest attainable point on his preference scale."

This is how Herbert Simon (1955), in one of his works about decision making, introduced the conception of bounded rationality as the basic condition of human rational choice. Decision making is, therefore, an intendedly rational process, but only limitedly so. Consequently, a large number of decisions are made in an ad-hoc manner under conditions of uncertainty and the decisions are only assigned their final meaning retrospectively. Karl Weick is one of the scholars who brought the concept of *sensemaking* into organizational studies with having that in mind. In sociology literature, sensemaking is the process by which people give meanings to their experience by retrospectively assigning meaning to past events and thereby shaping the organizational context for present and future events (see, for instance, Weick et al. 2009). In his analysis of sensemaking in the 1949 Mann Gulch disaster where thirteen firefighters died, Weick (1993) argues:

"Sensemaking is about contextual rationality. It is built out of vague questions, muddy answers, and negotiated agreements that attempt to reduce confusion."

The cognitive perspective is, in fact, a relatively common representation of the management decision making processes, because of the social systems' complexity that is inherent to every project. With that in mind, Jackson (2000), for example, makes a reference to some of the seminal work on soft systems:

"Checkland and Scholes (1990) reasoned [that] managers are absorbed by the pressures and concerns of their immediate environments. They act and react according to their personalities, knowledge, instincts and so on and are unlikely, on an everyday basis, to operate according to the rules of a methodology. Rather than being methodology driven they are situation driven. They may wish, however, from time to time, to step outside the hurly-burly of ongoing events to try to make sense of what is happening or to apply some structured thinking to proposals for change."

This situational approach could be the main reason why a very limited amount of articulated knowledge exists in the field of facility design. Design as a constructive activity is not so much prone to analysis and methodology-driven structure. In fact, the very nature of design, in a way, opposes analytical thinking. This situation is not different in other fields of design and new product development. Friedman (2003), for example, observed that:

"All knowledge, all science, all practice relies on a rich cycle of knowledge management that moves from tacit knowledge to explicit and back again. So far, design with its craft tradition has relied far more on tacit knowledge. It is now time to consider the explicit ways in which design theory can be built—and to recognize that without a body of theory-based knowledge, the design profession will not be prepared to meet the challenges that face designers in today's complex world."

Although design is a creative mental process, it is still being conducted mainly in the context of economic organizations. In this case, the economic goals of this decision making process should not be forgotten. In reality, the decision-making is not fully rational, but incorporates cognitive limitations of economic agents as elaborated above. This decision making constitutes the planning process of design in terms of economic decisions.

The interpretive nature, therefore, of the cognitive processes that constitute virtually every design and new product development process, there is a considerable gap between the research and practice of design. The cognitive approach has been already implemented into the construction context by contemporary scholars of construction project management (Winch and Maytorena 2009).

Applying the retrospective sensemaking reasoning to design in the built environment appears to be particularly advantageous to fill this gap in knowledge. The first set of advantages of this approach arises from the fact that taking an ex ante perspective would in a certain sense imply that the researcher knows more about the decision to be made than the decision maker, indeed, a situation that is highly unlikely to occur. Secondly, in a situation so complex and with so many participants, it is highly unlikely that all the decision makers are presented with the exact same information. For that reason, there will be a number of different interpretations of the analyzed event. In such cases, Weick and his colleagues argue, interpretation should precede choice as a unit of analysis (Weick 1993; Weick et al. 2009). This will form basis for the decision making process.

In conclusion, designers aim to think about problems first and set up a course of action correspondingly. However, due to the cognitive limitations in the design process, the meaning of actions can in many cases be reached only through retrospection. This constitutes the paradox of design that states that, although actions need to be planned for in advance, the true meaning of the plan only becomes available when the full range of its consequences are known.

3.2 Design Organization

Organizing the above described process of design is a challenging undertaking. Because the main planning problem constitutes in defining the problem itself, the form of organization should follow the ill-structured nature of design. Indeed, organizational hierarchies can cause problems in design consistency as people will use fragmentation of structure to delimit their domain of influence. As Rittel and Webber (1973) point out in one of the seminal works on planning theory:

"Under these circumstances it is not surprising that the members of an organization tend to see the problems on a level below their own level. If you ask a police chief what the problems of the police are, he is likely to demand better hardware."

This is precisely the reason why a design organization should be as flat as possible. In the traditional architect-led model, the responsibility of failed design would casually be passed back and forth from architects to engineers and vice versa. The same phenomenon holds true for the design/construction interface. The solution to this problem would be an ideally flat organization with equal contribution by the participants. Pahl and Beitz (1996), for example, advise the following strategy for engineering design in new product development:

"Simultaneous or Concurrent Engineering involves goal-oriented, interdisciplinary (interdepartmental) collaboration and parallel working throughout the development of the product, the production process and the sales strategy. It covers the total product life cycle and requires firm project management."

At least theoretically, this organizational strategy includes a flat professional organization where leadership is collaboration- instead of disciplinary-driven. The question of whether this kind of organizational structure is achievable within the built environment context is, however, subject to debate.

4. TOWARDS FINDING COMMON GROUND

This discussion suggests that the definition of design should be more inclusive than the current conceptualizations, to be able to represent reality more appropriately. At its most fundamental level, design can be categorized either as a disciplinary or phase-based series of interdependent activities that have, to date, mostly been elaborated independently.

- Phase-based conceptualization: In terms of a formal process model, such as the one published by the Royal Institute of British Architects (RIBA) (2007), those would be the tasks carried out as part of the *preparation, design, and pre-construction stages*.
- Disciplinary conceptualization: Based on the disciplinary domains, this would include a combination of the disciplines that participate in the design process: *real estate development, architectural, and engineering design*.

Covering all the above-introduced fields as constituent elements of design is purposeful because all of the components share characteristics of the planning problem. As a consequence, there is significant overlapping between the fields that can be observed at both the project and the firm levels of analysis. The most common property of the design process is that, as Cross and Knovel (2000) point out:

"...it can be easy for the designer to become trapped in an iterative loop of decision-making, where improvements in one part of the design lead to adjustments in another part which lead to problems in yet another part. These problems may mean that the earlier 'improvement' is not feasible. This iteration is a common feature of designing."

However, there are still some important differences between the components. These differences are mainly a result of domain-dependent approaches to the design problem. The three most widely cited categories of design are architecture, engineering, and software development (Lloyd and Scott 1995). Even when combined together, the different design disciplines need to adhere to the properties of the construction process. Firstly, the one-off and uncertain nature of construction projects requires significant innovation and improvisation in the design decision making process. And secondly, construction projects need to also meet their respective institutions. As construction projects affect their societies, environments, and economies for prolonged periods of time, those are the constraints that need to be addressed in the innovative development process.

What would, then, be a common ground for defining, executing, and managing design and how would a design in the built environment be defined? Overall, the nature of the design problem, not professional membership or educational background, dictates what a designer should do. As Cross (1982) defined the general design discipline, this should not be any different when applied to the built environment:

"Designers tackle 'ill-defined' problems, their mode of problem-solving is 'solution-focused', their mode of thinking is 'constructive', they use 'codes' that translate abstract requirements into concrete objects, they use these codes to both 'read' and 'write' in 'object languages'."

If designing is considered profession in its own right, from the above discussion it becomes clear that design is more aligned with the innovation industry than the service industry. Therefore an inclusive definition of design has implications not only for the activities themselves, but also at a level of public policy. Although the institutional context of design has in many countries been regulated as a service within professional "chambers" or similar formal entities, an inclusive definition implies that design belongs to the domain of innovation and should be regulated accordingly.

5. CONCLUSIONS

The built environment can be considered a physical embodiment of the information created in the decision making process for which this discussion coined the term design. In its broadest sense, the process of developing the built environment is a plan for bringing the project into physical reality by means of a construction process. This discussion has laid out the foundations for mapping out a conceptual landscape of facility design from multiple perspectives. The discussion firstly introduced the basics of the general planning problem and the interpretive sensemaking approach to analyzing the design problem. The discussion offers an inclusive definition of design management for the built environment, in which the process is not constrained to mere architectural design or engineering of systems to be fitted into the facility. It includes the entire range of decisions made by diverse stakeholders in a construction project. Design is also not constrained to the initial phases of the project, which is to be discontinued as soon as construction activities are beginning. It is a continuous process that does not stop at any point in time in the project. Design is not even finished when the facility is fully operating or building occupied. It stretches well into the lifecycle of the building with its maintenance and, even, demolishment.

The current concept of design management is the traditional division of labour along the design supply chain. One the one hand, urban planning and architectural design strongly implement criteria of aesthetic and social value into their processes, whilst focusing less on technical aspects of the project. On the other hand, however, engineering design is mostly considered a commodity in such a constellation of the process. In this representation, engineering is embedded into the architecture of the facility and, respectively, architecture is embedded into the urban planning of the area.

This paper differentiates between the *conceptual and detailing* components of each of the design processes. In this vein, each discipline, or part of the physical scope of the designed facility, reaches the concept solution in a different time-frame and subsequently elaborates the concept solution. In this representation, each part of the design affects its other parts. Therefore, the flow of design is not divided in terms of disciplinary boundaries, but in terms of conceptual solutions of each of its constituent parts. This view calls for tight integration of the conceptual design tasks within a flat and collaborative design organization.

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