Integral Design workshops: organization, structure and design

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ABSTRACT

The purpose of this paper is to achieve an understanding of design activities in the context of building design. Starting point is an overview of design research and design methodology. From the insights gained by this analysis of design in this specific context, we present a ‘organization structure and design’ workshop approach for collaborative multi-discipline design management. The workshops set-up, used to implement and to test the approach, are presented as well as the experiences of the participants. The project was done in close cooperation with the professional societies with in the Dutch building design field. More than hundred experienced professionals participated in the workshops. The workshops have become part of the permanent professional training program Dutch architectural society.

Keywords: integral design, morphological overviews, workshops

1. INTRODUCTION

In the design of buildings, the process of implementing the clients’ but also society’s needs and expectations is of great importance. During the last fifteen years attention has enormously increased to comfort in buildings and the consequences for the environment as results of Global Warming (Alley et al.2007) become more and more prominent. The design process became more heterogeneous, with several diverse actors involved such as architects, engineers, contractors and clients. The different viewpoints imply a need for cooperation: a collaborative approach to the design process. These changes have led to a shift in the role of the architect in the building design process. The former master builder with the responsibility for the totality has been reduced to merely an actor among others in the briefing and design phases of a complex project (Kjølle & Gustafsson 2007). Still architects have a larger influence on the crucial conceptual design decisions during the building design process and often act not as merely an actor but as conductor. Concepts as ‘team-work’ and ‘collaboration’ as collective terms for every interaction with other people are needed to deal with the complexity: collaborative design management is needed.

Currently within the context of Dutch Building Practice, it is difficult for the different disciplines in the design phase to give good answers on the built-environment-questions from society. As complexity and scale of design processes in architecture and in building services engineering increase, as well as the demands on these processes with respect to costs, throughput time and quality, traditional approaches to organize and plan these processes may no longer suffice (van Aken 2003). Inadequate design processes result in a productivity loss in the Dutch building industry of approximately about 10% of the total Construction Costs per year (USP 2004). To reduce these failure costs collaboration between the different design disciplines becomes increasingly difficult. Synergy between the different disciplines involved within the building design process is necessary to reach the best designs. No longer is it sufficient to merely solve the problems which arise at the level of detailing on the borderlines of disciplines.

In the world of design and engineering, gaps between the different fields can be recognized (van Aken 2003). Getting a better understanding of the design team’s role is essential for investigating of how to improve engineers’ and designers’ added value for the building design process. Yet, there is little understanding of what is required to design adequate on-site learn-work environments that directly facilitates learning with the learning and knowledge resources of the organization (Senge 1990, Suchman 1987). One of the complicating aspects in building practice is the different cultural back-ground of architects and engineers and their different approaches to design (Cross & Roozenburg 1992). There is a need to view all the different aspects of building design in a more integral way, resulting in an integral approach to building design. This integral approach can eventually lead to integral process, team and method – all the required conditions for design of the end product. This implies defining a process methodology that acts as a “bridge” between architectural aspects such as shape, color and style on the one hand, and the functions of par example indoor climate issues such as overheating and ventilation on the other hand.

2. METHODOLOGY

“Design aims at structuring the known data of nature in a way leading to an effective control of matter in relation to man’s need and wants” (Van den Kroonenberg 1978).

Integral Design

This already somewhat dated definition of design by van den Kroonenberg is strongly related to the new definition by Krippendorf (2006): Design is making sense of things. This leads to the central theme of this paper: to make sense of design. History is always a good starting point, so to start a short historical overview of design. The origins of new design methods in the 1960s were based on the
application of ‘scientific’ methods derived from operational research methods and management decision-making techniques in the 1950s (Cross 2007). The first design methods or methodology books appeared – Asimow 1964, Alexander 1964, Archer 1965, and Jones 1970.

However, in the 1970s came the rejection of design methodology by even some of the founding fathers themselves, such as Alexander and Jones. Fundamental issues were raised and design problems were characterized as ‘wicked’ problems, un-amenable to the techniques of science and engineering. This resulted in a proposal for a new generation of methods by Horst Rittel, moving away from attempts to optimize and towards recognition of satisfactory or appropriate solutions (Simon 1969). In the 1980s engineering design methodology of the systematic variety developed strongly. A series of books on engineering design methods began to appear; Hubka 1980, Pahl and Beitz 1984, Cross 1984 and French 1985. In fact, after the risen doubts of the 1970s, the 1980s saw a period of substantial revival and consolidation of design research. Since then there was a period of expansion through the 1990s right up to day: design as a coherent discipline of study was definitely established in its own right (Cross 2007). Still there is no clear picture (Horváth 2004, Bayazit 2004) and many models of designing exist (Wynn & Clarkson 2005, Pahl et al. 2006). That makes it difficult to choose and implement design models in practice.

During early 1970s a prescriptive design process model was developed (Blessing 1994): methodical design, based on the combination of the German (Kesselring, Hansen, Roth, Rodenacker, Pahl and Beitz) and the Anglo-American design schools (Asimov, Matousek, Krick). This model was extended into an integral design model. A distinctive feature of the integral design model is the four-step pattern of activities that occurs on each level of abstraction with the design process. The design process becomes more transparent and this increases the possibility to reach synergy between the different disciplines and/or client involved in the design process, see figure 1.

The approach by van den Kroonenberg is similar to the Integrated Product Development (IPD) by Andreasen (Andreasen and Hein 1987, Buur and Andreasen 1989). This model is similar to the chromosome product model by Malmqvist as adapted from Andreasen (Malmqvist 1995). Still Methodical Design has some special characteristics; “it is one of the few models that explicitly distinguishes between stages and activities, and the only model that emphasis the recurrent execution of the process on every level of complexity (Blessing 1993, p.1398”).

An important feature of this model is use of morphological charts which makes it possible to address client’s needs on higher abstraction levels than the program of requirement.

Morphological chart

Morphological charts were developed by Fritz Zwicky in 1947 (Norris 1963) as a tool for investigating the totality of relationships contained in multi-dimensional, usually non-quantifiable problem complexes (Ritchey 1998). Morphology provides a structure to give an overview of the considered functions and aspects and their solution alternatives. The functions and aspects are derived from the program of demands which defines the outcome of the design process. Possible solution principles for each function or aspect are then listed on the horizontal rows. Different overall solutions are created by combining various solution principles to form a complete system combination (Ölvander et al. 2008).

Transforming the program of demands into characteristics for input and output (aspects) and formulation of the different relations between input and output (functions) to fulfill, leads to the construction of a morphological chart, see figure 2.

The morphological overview gives a complete overview of aspect elements or sub-solutions that can be combined together to form solutions. Morphological Charts are essentially tools for information processing, it is not confined to technical problems but can also be used in the...
development of management systems and in other fields (Pahl, Beitz et al., 2006). Morphological chart structure the solution space and encourage creativity. The morphological charts can also used in conjunction with overall design processes such as 6-3-5, brain writing, reverse engineering and redesign method (Bohm et al. 2008). Especially morphological charts to visualize solution alternatives play a central role in multi disciplinary design teams.

Morphological Overview
By combining the different morphological charts made by each discipline and combining them to one overall overview after discussion and selection a morphological overview is generated, see figure 4 and 5. Such a morphologic overview can be used by the designers to reflect on the results during the different design process stages. Using morphological charts as a tool and to transform it into a morphological overview, others’ contributions activate individual interpretation, the reflection of a designer, based on which he or she can make the decision to also make an explicit contribution. By utilizing morphological overviews in this way, a reflective step is introduced within the design process, forcing reflection between individual designers and making actual reflection-in-action on a design team level possible. Thus rational problem solving is integrated with reflective practice (Schön 1983). The reflection within the integral design method represents potential for the creation of new integral solutions through the integration of discipline based knowledge into integral design concepts.

A morphological overview can be generated by combining the different morphological charts made by each discipline. After discussion on and the selection of functions and aspects of importance for the specific design the designers with different disciplines based backgrounds can agree on the elements from the separate morphological charts to form the morphological overview, see figure 3 and 4. Such a morphologic overview can be used by the designers to reflect on the results during the different design process stages.

3. EXPERIMENTS
Since 2005 we organized 5 series of workshops with experienced professionals, architects and engineers, voluntarily applying to participate. The participants of each discipline were randomly assigned to design teams, which ideally would consist of one architect, one building physics consultant, one building services consultant and one structural engineer. Starting with a three day practice-like ‘building team’ concept, in which all disciplines are present within the design team from the start, the integral design method workshops have evolved to finally a two-day series. In the first workshops we also introduced the Kesselring method of decision support, based on this is the VDI 2225 (Zeiler et al. 2008) but it proved to be an information overload for the participants. Therefore we focused on the use of the Morphological Overview as design tool. More information about the first three series of workshops can be found in (Zeiler et al. 2005, Savanovic and Zeiler 2007). The experiences of workshops series 3 led to adjustments for the final workshops series 4 and 5, see figure 5.

The 4th workshop was held in May 2007 and the 5th workshop was held in February 2008. In the current configuration (Figure 6) stepwise changes to the traditional building design process type, in which the architects starts the process and the other designer join in later in the process, are introduced in the set up of the design sessions. Starting with the traditional sequential approach during the first two design sessions on day 1, which provide reference values for effectiveness of the method (amount of integral design concepts); the perceived
“integral approach” is reached through phased introduction of two major changes:
(1) all disciplines start working simultaneously within a design team setting from the very beginning of the conceptual design phase,
(2) the integral design model / morphological overviews are applied.

The second set up of the design sessions allows simultaneous involvement of all design disciplines on a design task, aiming to influence the amount of considered design functions/aspects. Additional application of morphological overviews during the set up of the third design session demonstrates the effect of transparent structuring of design functions/aspects on the amount of generated (sub) solution proposals. Additionally, the third setting provides the possibility of one full learning cycle regarding the use of morphological overviews.

4. RESULTS

Over the past four years the above described approach was tested in a series of 5 workshops, these typically include around twenty participants and lasted for two or three days. A total of 108 designers participated in a four workshop series, in which 74% of the designers were present during all days. The average age of the participants, either architect or engineer was 42 and they had on average 12 years of professional experience. Direct at the end of the workshop the participants were asked to fill in a questionnaire in which questions were asked about the importance of the use of morphological overviews within the design process and about the concept of the workshops themselves. The participant had to rate between 1 (very poor) to 10 (excellent), the different aspects and their results were then transformed to an average group rating see figure 6.

The results of the questionnaires indicate that the participants of the workshops thought the use of morphological overviews of value to communication and the number of relevant alternatives within the design process. The improvement in the workshops setting is clearly seen on almost all aspects. Remarkable is the lowest rating by all participants for the aspect of the positive effect of morphological overviews on the final design. Also the rating of people for the expectation to use morphological overviews in practice is rather low.

Participants of the five series workshops were approached six months after their workshop participation in order to get their ‘second opinion’. Only the reactions from designers who participated during all design sessions of a series were taken into account. The number of participants is given in table 1.

![Figure 5: Workshops series 4 & 5, four different design set ups of participants and Morphologic Overviews (MO) during the design sessions within two days.](image)

![Figure 6: Overview results questionnaires participants professional workshops series 1 till 5.](image)
morphological overviews of all the different disciplines of almost 25%. Still on average 40% of
the participants used morphological overviews in their practice. What we can see is the relative low
score for building physics consultants and building services consultants. They both normally come in a
later phase of the design process often after the conceptual design phase. This meant that they could
not introduce the morphological overview anymore. Also most of the participants were working in large
ongoing projects which already were past the conceptual design phase. That might be the
explanation of the low score.

Figure 7: Results questionnaires on different aspects of the use of MO’s of workshops series 1 to 5 after a working period of six month’s

5. DISCUSSION

Although the basis of the applied method, Morphology, was created by Zwicky after the 2nd
world war there is still a lot of development going on. There is of course the work of Kristin Wood and
Robert Stone in the United States (Kurfman et al. 2001, Hutcheson et al. 2007) but this is focused on the
functional modeling in the mechanical engineering domain. The work of Tom Ritchey is
more aimed at problem structuring analysis (Ritchey 2006). A systematic method utilizing
morphological analysis in ‘cross-functional teams’ was developed within a running product
development project of a Swedish car manufacturer (Almefelt 2005a, Almefelt 2005b). Reflecting the
specific industrial and theoretical background, the main idea of the method was to support ‘early
balancing of properties’ when synthesising a product concept: ‘a method highlighting synergies’.
The aim of that project was to demonstrate, explore, and evaluate method’s practical effects in use; its
application in design and in design teams is not new at all we think that the cross cultural
multidisciplinary experiments we undertook add some new and interesting insights. Especially as the
often rather strict function-based modelling from the mechanical domain is not enough to cope with
besides functions aspects like style, atmosphere, color, sustainability etc. Besides that there is more
to functions than often is assumed as argued in the work of par example Pieter Vermaas (van Eck et al.
2007). Though not strict defined all practitioners have a workable understanding to work with the
concept of functions and aspects. We think that the Morphological Overviews can work like a kind of
‘conceptual drawbridge’ the technical functions in there own are a drawbridge between the intentional
and structural natures of technical artefacts (Vermaas and Houkes 2006).

6. CONCLUSIONS

The focus in this paper was on the implementation and testing of the Integral Design method in 5 series
of workshops in which experienced professionals from BNA (architects) and ONRI (consultants)
participated. The workshops led to the following conclusions;
- morphological overviews helps to structure and develop knowledge of design team members
- implementing the new Integral Design approach is only practically possible at the beginning of a
project
The experiences of participating architects with the workshops Integral design were so good that since
2007 the workshops have become part of the permanent professional education program of BNA
and since 2009 also for the engineers. We think that this is the best prove of the value of our presented
approach.

7. ACKNOWLEDGMENTS

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8. LITERATURE

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