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REFLECTION IN BUILDING DESIGN ACTION: MORPHOLOGY

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ABSTRACT

Buildings are no longer just a collection of building materials but have an increasing amount of technical installations inside. The mechanical engineering part of the design has become a major part of the design and construction of buildings. Building design involves multi-disciplinary design teams in order to integrate contributions to solve the complex design task from different perspective such as architecture, construction, building physics and building services. To support this highly complex process the Integral Design method is used as a framework for structuring the design process and the reflection on the design process itself. By using multi-disciplinary morphological overviews, derived from the combination of mono-disciplinary morphological charts, communication can be structured between design team members. Morphological overviews offer the possibility for reflection on the design results by the design team members and their stakeholders. With the help of the C-K (Concept-Knowledge) theory of Hatchuel and Weil, we especially focus on the generation of new concepts/ new design knowledge resulting in increased number of alternative in the conceptual design phase. Using C-K enables to distinguish different steps in the design process more clearly. This method was tested in workshops for professionals from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (ONRI). In the last 5 years over 250 professionals have participated in these workshops and they have become part of the permanent professional education program of the Dutch architects since 2007.

Keywords: Integral design, Morphology, Design tool, Design teams

1 INTRODUCTION

People want to feel comfortable in their houses and offices. Therefore buildings are equipped with advanced heating-, ventilation-, and air-conditioning-systems. The building services installations need a lot of energy and nowadays there are strict regulations for that energy consumption meant to drastically reduce it. To reduce the energy consumption and at the same time improve comfort leads to complex building design tasks. No longer the architect can do the conceptual design on his own, an integral design process is needed in which all designers from the different disciplines start together for the project beginning. Traditional approaches to organize and plan this highly complex building design process ceased to be sufficient (van Aken 2003). We looked at design methodology as a route to the solution. As stated by Cross (2001), design methodology includes the study of how designers work and think, the establishment of appropriate structures for the design process, the development and application of new design methods, techniques and procedures, and reflection on the nature and extent of design knowledge and its applications to design problems.

At present there is a gap between design theory and design practice, in the building industry. Methods are needed to bridge the gap between the worlds of Prescriptive Design Methodology and Reflective Practice, and to look at designing as a process in which the concepts of function, behavior and shape of artifacts play a central role (Vermaas & Dorst 2007). Such integrated approach shows high promises to reduce failure costs and improve design quality can eventually lead to integral process, team and method – all the required conditions for design of the end product; the building (Seppänen et.al 2007). That is why the building design community is showing a growing interest in design methods as a supportive framework for the building design process.

2 METHODOLOGY

2.1 Structuring design

Due to the need for more effective design in the 70's prescriptive German models (Hansen, Koller, Roth, Hubka, Pahl, Beitz) were developed with the focus on the design process as a systematic generation process of solutions. The approaches of the Anglo-American school (Asimov, Archer, Greogory, Krick, Jones) generally extend the design models focus to the process of concept generation based on the analysis of the initial product idea.

In the mid-80's the focus moved more towards descriptive design methodologies which focuses on the 'description of a sequence of activities that typically occur in design' (Cross 1989). The rational, systematic approaches to designing in architecture, engineering and product design were been challenged by design theorist Schön (1983). He claimed that design research can only be relevant to practice if it recognizes the ambiguities and complexities of real design practice, and if it succeeds in developing a better understanding of design as it occurs in everyday design situations (Roozenburg et al 1998).

Design cannot validly be studied and modeled in complete isolation. The possibilities of the current modeling of design with a prescriptive approach have to be explored (Buccialli 1994) and can provide a framework for the description and explanation of the context-dependencies of designing (Dorst & Hendriks 2000).

The approach of reflective-practice (Dorst 1997) describes the tackling of fundamentally unique problems. Schön proposes an alternative epistemology for design practice, which describes design as 'reflective conversations with the situation' (Reymen 2001). Combining aspects of the reflective practice (Schön 1983) in the interpretation phase with the prescriptive design method in the conceptual design phase will help to overcome a major obstacle: it will form a basis for multi-disciplinary team design as a prerequisite for effective actions during building design processes.

So, it is not surprising that design thinking – the cognitive processes that are manifested in design action – has become recognized as a key item of research for understanding the development of design practice and design education. In the past simplifying paradigms have been attempted– such as viewing design simply as problem-solving, or information-processing, or decision-making, or pattern-recognition – and all have failed to capture the full complexity of design thinking (Cross 1991). Designers specifically know the "artificial world', the human-made world of artifacts. Designers know how to propose additions to and changes to the artificial world. Their thinking, knowledge, skills, and values lie in the techniques of the artificial (Cross 2001). Prescriptive methods for structuring design processes based on the existing theories of design still predict designer's actions only on an overly abstract level. This a model for design thinking is based on a simplified model by de Vries (1994). Consider an individual designer working on a design problem here two worlds can be distinguished connected to the activities taking place. One world consists of the design object, the object description and the design knowledge all part of the real world: the knowledge world K, while there is also a hidden undefined conceptual world in the mind of the designer, see figure 1.

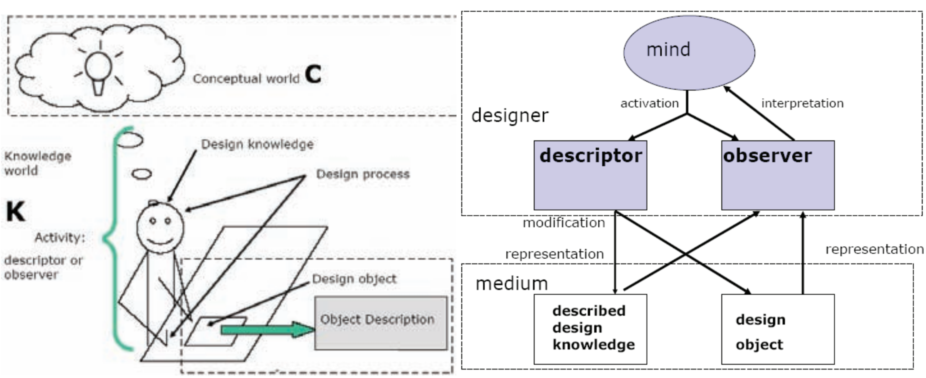

Figure 1. Designer and World view (de Vries, 1994) and Interaction model of designing within a team with changing role of the designer as descriptor or observer

Essential are different roles of a designer, he is descriptor of the design object and as soon as he has scetched or described the design object he becomes also an observer within his own design process. When we look at a representation of a design team, we can more easily sea the different roles, because when one designer is active as descriptor the other automatically become observers till they become active and the roles are changed, see figure 1. This figure shows the dualistic role pattern of a designer. Sometimes he descriptor of his own activated mental design process. While on other moments in the design process he observes the activities of the other design team members. This rather simple model provides us a basis to look into design process.

2.2 Integral approach to the problem: Methodical design as basis

Starting from the prescriptive model of Methodical design (van den Kroonenberg 1974) , we developed a way to articulate the relationship between the role of a designer as descriptor or observer within a prescriptive design method and reflect on the process. Methodical design was chosen as a starting point of development because it has exceptional characteristics (Blessing 1994): it is a problem-oriented model; it is one of the few models that explicitly distinguish between strategies, stages and activities; it is the only model that emphasizes the execution of the process at every level of abstraction. The Integral design model, though based on methodical design is an extended design model; the cycle (define/analyze, generate/synthesize, evaluate/select, implement/shape) forms an integral part in the sequence of design activities that take place. So a distinctive feature of the integral design model is the four-step pattern of activities (generating, synthesizing, selecting and shaping, see figure 2), that occurs on each level of abstraction with the design process.

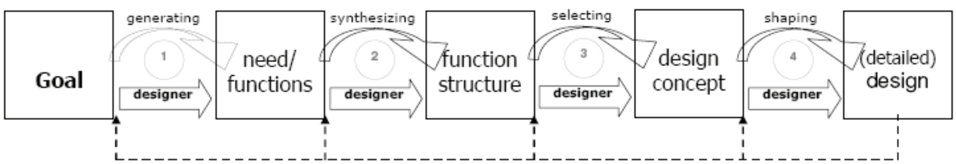

Figure 2. The four-step pattern of Integral Design with possible iteration loops

A distinguishing feature of Integral Design is the use of morphological charts for design activities in each phase of the design process. Morphological charts were first used by Zwicky (Zwicky 1948, Zwicky and Wilson 1967). Zwicky (1948) gives a clear description of the morphological method; *"The morphological method essentially is nothing more than an orderly way of looking at things. The only innovation which we propose is to carry morphological thinking to a degree of generality not commonly realized. Our aim is to achieve a schematic perspective over all of the possible solutions of a given large-scale problem. Naturally not all of the solutions which we are thus led to visualize can be carried out individually in all detail. Because of unavoidable limitations on time and means a choice must obviously be made, and preference must be given to some specific solutions. With the general perspective achieved, this choice will however be more rational and organic than it would be if one engaged haphazardly in work on this or that solution of a given problem".*

The morphological chart is formed by decomposing the main goal of the design task into functions and aspects which are listed on the first vertical column of the chart which consist of a column and connecting rows, 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). 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). 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).

By using morphological charts each discipline can look for completeness: if all necessary functions and aspects are listed. All the design team members now have the challenge to come up with their interpretation and possible solutions to the design task. As every designer sees the results immediately in the morphological chart, they can discuss aspects which are not clear to them. Immediately the reflection in action on the design process is initiated if the designers make the morphological chart together.

Using the morphological charts made by each individual designer, we can combine them to a morphological overview, see figure 5. The advantage of this approach is that the discussion comes after the preparation of the individual morphological charts. As each designer uses his own interpretation and representation, in relation with his specific discipline based knowledge and experience, this gives an overview of different interpretations of the design brief resulting in a domain specific morphological chart. This allows a greater freedom of mind of the individual designers and results in more creativity in interpretation of the design problem and generation of part solutions from the different disciplines. The whole process is done in two steps first the functions and aspects are discussed and then the possible related solutions see figure 3.

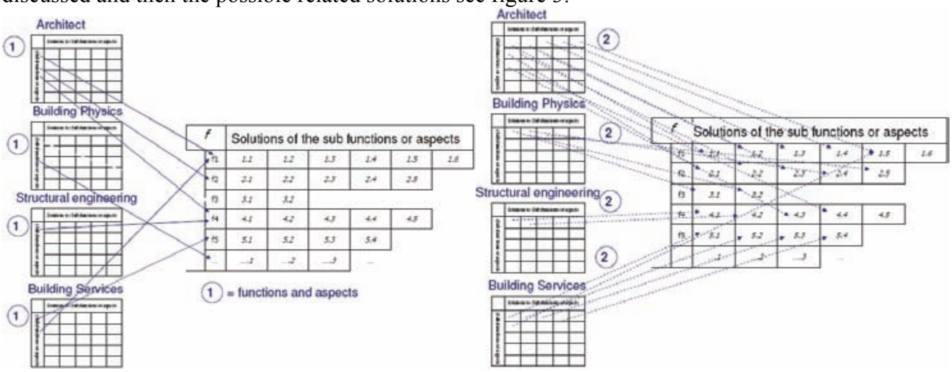

Figure 3. Building the morphological overview; Step 1; The Morphological overviews show the agreed functions and aspects (1)of the different morphological charts. Step 2: The Morphological Overview with the agreed on sub solutions (2) from the separate morphological charts

Especially morphological charts to visualize solution alternatives play a central role. A morphological overview is generated; see figure 5, 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. Such a morphologic overview can be used by the designers to reflect on the results during the different design process stages. Although the use of functional description and morphological charts is common practice in mechanical engineering design, they are rarely used in a multi-disciplinary way besides engineering. Especially the input of 'soft' aspects adds a new dimension to the strict functional approach of traditional morphological chart. The morphological overview makes it possible to change from "Form follows Function " (Sullivan 1896) to a new way of conceptualizing design as a professional practice in which design is making sense of things (Krippendorf 2006): hard and soft things. Generally speaking, design thinking is a creative process based around the transformation of needs into solutions. In this process existing knowledge and information about the actual needs of the principle forms the basis to work from. This often has to be transformed into new unknown concepts if solutions based on existing knowledge are not adequate. So in that case we have to develop from the known the unknown. As such we can make the distinction between the known (knowledge) and the unknown (concepts) this distinction determine the core propositions of C-K theory (Hatchuel and Weil 2007).

3 CONNECTING INTEGRAL DESIGN AND REFLECTIVE PRACTICE

3.1 C-K theory

In the C-K theory concepts and knowledge are distinguished. This theory defines design as a process generating co-expansion of two spaces C-K. There is no design if there are no concepts. Without the distinction between the expansions of C and K, design is reduced to mere optimization. In our view, optimization through merely (re)combination of already existing object design knowledge leads only to redesign;

- Space K. Contains all established (true) propositions (the available knowledge, existing solutions). A piece of knowledge is a proposition with a logical status for the designer or the person receiving the design. A set of knowledge is therefore a set of propositions, all of which have a logical status (Hatchuel and Weil 2002).
- Space C. Contains “concepts” which are undecidable propositions in K (nor true nor false in K) about some partially unknown set of objects called a C-set. A concept is a notion or proposition without a logical status: it is impossible to say that a concept, for instance an "oblong living room", is true, false, uncertain or undecidable. A concept is not "knowledge" (Hatchuel and Weil 2002).

The transformations within and between the concept and knowledge spaces are accomplished by the application of four operators (Hatcheul, Le Masson and Weil, 2004): K-C, C-K, C-C and K-K. The last two operators are internal to the concept and knowledge spaces, and are not particularly relevant to the expansion of both. The first two operators cross the Concept-Knowledge domain boundary, and are significant in the sense that they reflect a change the logical status of the propositions under consideration by the designer (from no logical status to true or false, and vice versa). Within the integral approach the space K is defined by the initial design knowledge that participants bring into design team. (Sub)solutions are seen as ‘chunks’ of “object design knowledge” (Van Aken, 2005), which is mainly discipline based. Since the object of design is used as the reference, this knowledge is further specified as initial object design knowledge iODK (Figure 4). Only explicitly presented / communicated object design knowledge within a design team is considered and the focus is on how this explicit object design knowledge is transformed / integrated within a multi-disciplinary design team setting. Making object design knowledge explicit enables designers to use it for the creation of design concepts. These concepts are either integral (IDC) or just plain combinations (RE).

Concepts acquired by only combining (sub) solutions are regarded as redesigns (RE). Although a given combination might take all relevant aspects (defined by design team itself) into account, it doesn’t represent an integral solution. See step 3 - combining [activities] in figure 4. Working out specific functions / solutions on a lower abstraction levels, optimize chosen redesigns will gradually lead to detailed solutions (shaping phase).These are optimized i’ODK, see step 4 in figure 4.

Concepts acquired through transformation of iODK into ID, see step 3’ in figure 4, and are regarded as integral concepts. This is a result of so-called designer’s ‘creative leap’, triggered by (aspects of) presented (sub) solutions and their possible connections. Implicit knowledge is regarded as the other catalyst. Through evaluation of ID-concepts, new object design knowledge emerges (C-K theory) since iODK is not sufficient for explanation. This nODK represents potential for creation of innovative design solutions. See figure 4 step 4’ - evaluating [activities]. The focus is on the possibility of expanding the concept space with integral design concepts (step 3’- Figure 4, ID), in order to produce potential for creation of new object design knowledge (step 4’- Figure 4, nODK). From a standpoint that a concept not being true or false (within space K), the design process aims to transform this concept and will necessarily transform K (Hatchuel and Weil 2003).

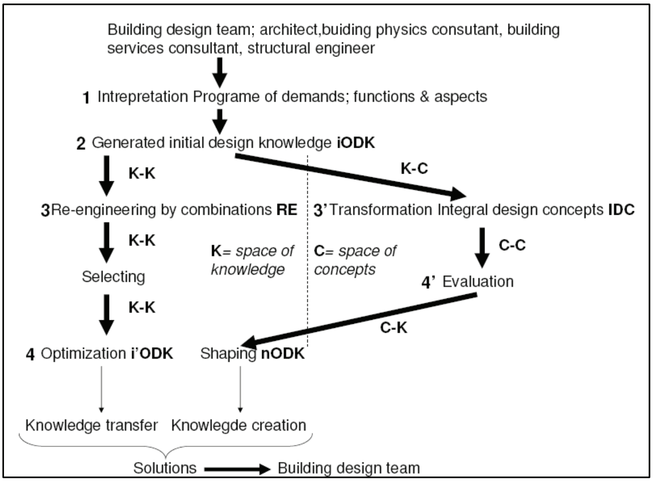

Figure 4. C-K Design process scheme

3.2 Morphological reflective overviews within C-K theory

Now we introduce the morphological overview from the prescriptive Integral Design model. A morphological overview is the result of the combined individual morphological charts of the different design team member after discussion on which aspects and function of the different morphological chats are put in the over scheme of the morphological overview. Using morphological charts and to transform it into a morphological overview, others' contributions activates discussion and results in a consensus about the most important aspects and functions. The individual interpretation, the reflection of a designer, is started now from a group perspective based on which the individual designer can make the decision to also make an explicit contribution from his own morphological chart (see Figure 5, symbol 2). Since the object of design is used as the reference, this knowledge is further specified as initial object design knowledge (Figure 5, symbol 2). From these contributions new combinations can occur, (Figure 5, symbol 3). 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. The reflection within the integral design method represents potential for the creation of new object design knowledge through the integration of discipline based explicit object design knowledge into integral design concepts (Figure 5, symbol 3').

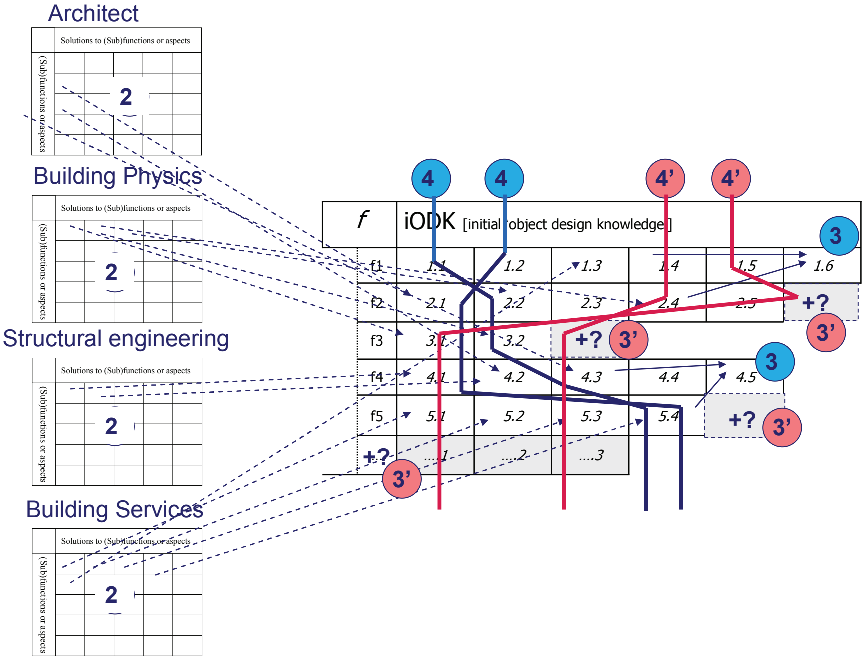

Figure 5. Morphological overviews show the initially available object design knowledge (-2). The combined morphological charts form the morphological overview which shows redesign combinations (-3) and the occurrence of integral design concepts (-3')

These integral design concepts are not merely a variation or combination of existing solutions but have some completely new element or characteristic not found before, (see the ***?*** symbol in Figure 5). This is the result of an implicit concept that arises by means of an often autonomic creative mental process by one of the design team members. So there is made a connection from the space K to space C of the C-K theory of Hatchuel and Weil. In figure 6 the connection between the C-K theory of Hatchuel and Weil and the morphological approach of the integral design method is presented.

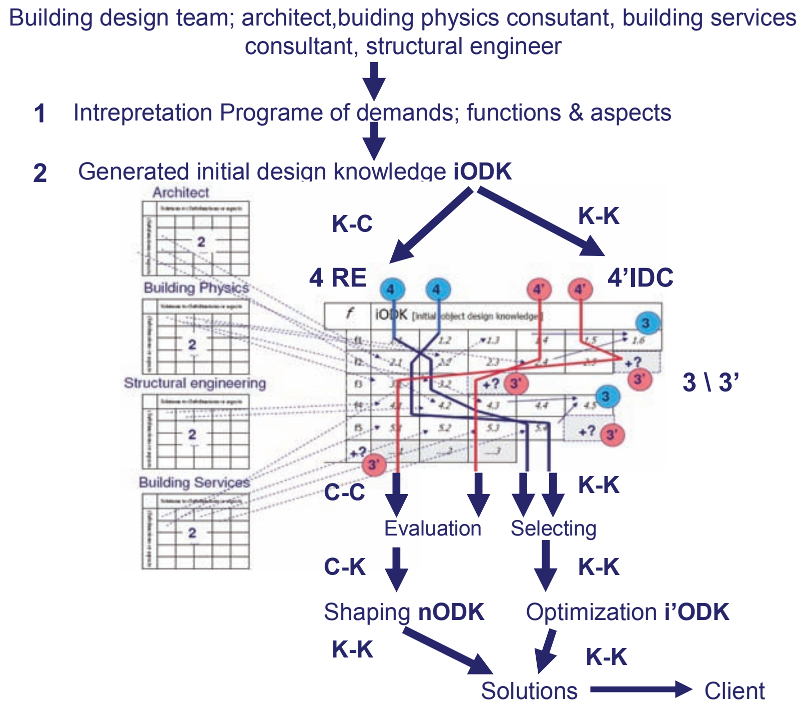

Figure 6. Morphological overviews and the C-K theory process scheme combined

Using morphological overviews as a design tool all interpreted functions and all generated (sub) solutions, represented by 'chunks' of object design knowledge, can be structured. In the integral design method morphological overviews can be used for interpreting the actions of the designers; a descriptive / reflective focus on the prescriptive Integral design method with the use of its process elements with morphologic overviews.

4 EXPERIMENTS

To test our approach of the morphological overviews and to look if the theory led to positive effect for the professionals, we arranged workshops as part of a training program for professionals. Essential we were interested in the use of morphological chart and morphological overviews, out theoretical pre-assumption is represented in figure 7.

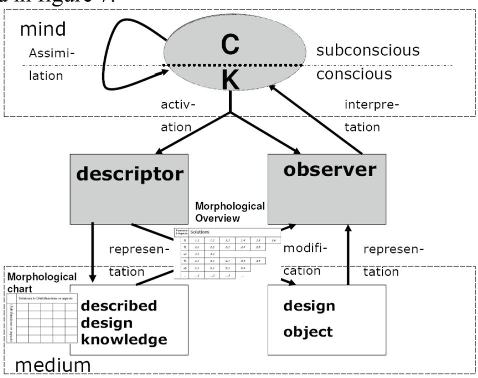

Figure 7. Interaction model within a team with the designer as descriptor/observer

4.2 Integral Design workshops 'learning by doing'

The first workshops were organized during 'Integral Design' project that was conducted by the Dutch Society for Building Services (TVVL), the Royal Institute of Dutch Architects (BNA) and Delft University of Technology (TUD), which involved mainly architects and building services consultants. The main focus of that project, which was initiated in 2001 and ended in 2003, was to raise the awareness of different disciplines about each others positions and problems in relation to building design. During this project a total of seven workshops were organized. This led to a following up project in which the workshop model was evolved further into a concept of 'learning by doing'. In this project the BNA, TNO Bouw (Dutch Institute for applied scientific research in the built environment) and the Dutch Association of Consulting Engineers (ONRI) participated. The experiences of the first three workshops 'learning by doing' series led to a final setup for the workshops series 4 and 5. The 4th workshop was held in May 2007 and the 5th workshop was held in February 2008. Essential element of the workshop were besides some introduction lectures the design cases on which the teams of 3 or 4 designers had to work and which they had to present at the end of each session to the whole group. These design exercises were derived from real practice projects and as such as close to professional practice as possible. In the current configuration (Figure 8) 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. All the sessions were put on video tape and photographs were taken every ten minutes. The end presentations and all material, sketches etc. was also photographed.

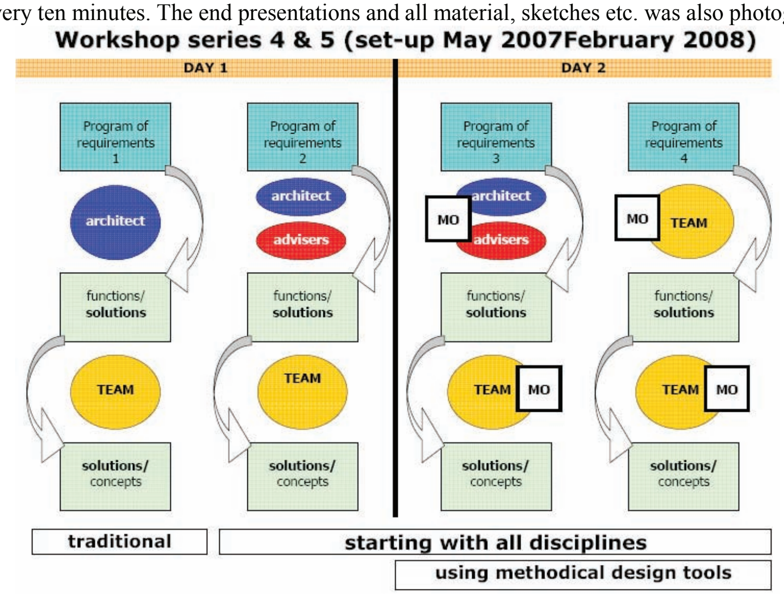

Figure 8. Workshops series 4 & 5, four different design set ups of participants and Morphologic Overviews (MO) during the four design sessions within two days

5 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 the five workshop series. 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. 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.

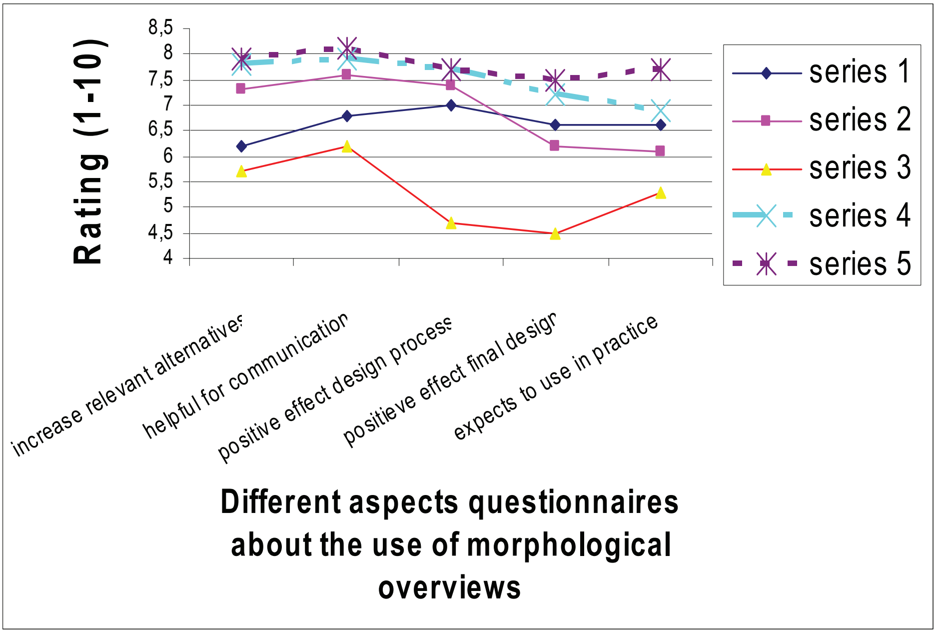

Figure 6: Overview results questionnaires participants workshops series 1 till 5.

6 DISCUSSION

As can be seen the last set up of the workshops was rated highest by the participants, with only a small difference the series 4 and series 5 which had the same final set-up. 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. Research on the relationship between design and the creation of knowledge is a relatively recent phenomenon (Heylighen et al. 2009), especially in architecture designers tended knowledge as a hindrance to unfettered creativity. So maybe it is hard for them to admit that knowledge and structure really helps the process. The analysis of the workshop series we organized in the past years showed that morphological overviews actually can provide this knowledge. This has eventually lead us to the idea that morphological overviews, besides being introduced as a tool for integral design process (together with the notion of working on different abstraction levels), could also be used as a research tool for observation of the design process itself to look in detail which steps and action were explicit made. By visualizing the (relations between) contributions within a design team, morphological overviews can show how design concepts are emerging within design team setting. The black-box of the 'creative leap' could be visualized as steps in the morphological overview development. That aspect, however, requires much more research. The quantitative/detailed analysis of the results of the seven years and 250 participants is lacking in this paper but will be presented in future work.

Although some might say that workshops are not a real experiment and that there are no controls, no measurements possible like in a real experiment we have some arguments why we never the less choose this approach. The workshop setting of a team in the conceptual phase of design is a common situation in Dutch practice, when the integral design approach is applied meaning normally that from the beginning all design team members start together. To use human subjects in laboratory experiments to study design theory provide some insight. However, extending results from laboratory experiment to conclusions for the engineering practice is a risk. The effect of Macro cognition describes the differences in cognitive functions performed in natural – versus artificial, laboratory – settings. The real-world setting requires activities in ways that artificial settings can rarely simulate. Schön (1987) has proposed a practicum as a means to 'test' design(ing). Where a practicum is" a virtual world, relatively free of the pressures, distractions, and risks of the real one, to which, nevertheless, it refers (Schön 1987, p.37)". In Schön's practicum a person or a team of persons has to carry out the design. A practicum can asses a design method and the degree to which it fits human cognitive and psychological attributes (Frey and Dym 2006). Crucial is the simulation of the 'typical' design situation. A workshop can be seen as a specific kind of practicum. It is a self-evident way of working for designers that occurs both in practice as during their education. As such a workshop provides a suitable environment for testing the approach. Besides full design team line-up there are a number of other advantages of workshops with regard to standard office situations, while at the same time retaining practice-like situation as much as possible. Workshops make it possible to gather a large number of professionals in a relatively short time, repetition of the same assignment and comparison of different design teams and their results. Never the less the workshops are a virtual world; "contexts for experiment within which practitioners can suspend or control some of everyday impediments to rigorous reflection-in-action (Schön 1983 p. 162). Schön refers further to the dilemma of rigor and relevance in professional practice, there is a choice to stay on the high, hard ground ("A high, hard ground were practitioners can make effective use of research-based theory and technique") , or to descend to the swamp ("a swampy lowland where situations are confusing") and engage the most important and challenging problems? (Schön 1983 p. 42).
Although morphological chart can be used effectively without any theoretical back-drop, the use of the C-K theory and its application of the four operators (K-C, C-K, C-C and K-K) enables us to focus on the transformation that take place in the design team between the individual designers and look into possible mechanism to stimulate elements of the process. The abstract representation helps to look for formalism that could support the team in their quest for solutions in their world full of ill-defined, "wicked"problems. The research was performed on the boundaries between design and scholarly research but in the end the focus was on design itself and that meant that the results were not validated against some criteria but by criteria of the workshops participants themselves. Did the approach had some added value for them? The results of the questionnaires indicate that this was the case on most aspects, though not on all. This is also a important aspect for further analysis of the workshops.

7 CONCLUSION

New approaches in building design are needed which look at conceptual designing as a knowledge development process that needs to be supported with appropriate tools. This article provides an insight into how morphological overviews can be used as a design support tool within the integral design method and based on the C-K-theory (Hatchuel & Weil 2009). Through visualization of contributions within a design team, morphological overviews can show how (integral) design concepts are emerging within design teams. By structuring design (activities) and communication between design team members, morphological overviews form the basis for reflection on the design results; both by the design team members themselves and in discussion with external parties such as the project manager. Through the application of the integral design method each step within the design process becomes transparent, which makes it possible to reflect on all design steps.

The Integral Design method makes it possible to work in a structured and transparent way using morphological overviews. We introduced the morphological overview as element of the prescriptive Integral Design method and used its morphological overviews as a descriptive element for reflective practice. Thus in one way the morphological overview is used in a prescriptive way as a tool to structure the information from and the communication between the different design disciplines

involved in the conceptual phase of the design process. In the other way the morphological overview is used descriptive to reflect the ideas and actions of the design team members.
We see morphological overviews as a valuable tool as well in the processes of the development of new design knowledge as in the analysis of this development. Morphological overviews can structure the design (activities) and the communication between design team members, forming the basis for reflection on the design results; both by the design team members themselves as in external discussion (with the client, but also for education and research purposes).

The tests of the integral design method were conducted through workshops with building industry professionals from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (ONRI). From 2001 till 2008 over 250 professionals participated in these workshops. There experience was such positive that the workshops are developed into a regular design course which is now part of the professional permanent educational program of BNA and part of the course program of TVVL (Dutch Technical Society of Building Services engineers), the Dutch equivalent of CIBSE (Chartered Institute of Building Service Engineers) and ASHRAE (American Society of Heating Refrigerating Air-conditioning Engineers).
The focus in this paper was on the implementation of the Integral Design method in an "learning by doing" workshops approach developed throughout 2005-2008 and tested in 5 series of workshops in which professionals from BNA (architects) and ONRI (consultants) participated.
The experiences of the workshops for multidisciplinary professional design-teams led to the following conclusions;
- morphological overviews as a design tool from the Integral Design method for multi-disciplinary design teams helps to structure and develop knowledge of design team members and is a supplement to develop / effectuate the integral approach / integral design.
- the use of morphological overviews improves the communication within multi-disciplinary design teams
- the use of morphological overview increases the insight of a designer in the different other disciplines
- the use of morphological overviews increases the number of relevant design alternatives
- workshops are an effective tool to couple practice / research / education

Although the workshops served research purposes, rather than the practice of designing, the experiences of participating architects from BNA with the workshops Integral design were so good that since 2007 the workshops have become part of the permanent professional education program of BNA. We think that this is the best proof of the value of our presented integral morphological C-K design approach for industry and that is the best evidence of the advantages of the proposed methodology for practical designers.

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