TOOLS AS A SYSTEMATIC INTERVENTION: INTEGRAL DESIGN

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The built environment is facing major changes. Traditional ways of building design are not sufficient anymore. Buildings have to become more sustainable. Therefore it is necessary to change the way we design buildings. One change could be the use of design methods with their design tools. We tested an Integral approach to merge the involved different designers to come up with new sustainable solutions. Stimulation of concept generation is also very important to achieve the necessary innovation of the built environment.

Keywords: Integral design, creativity, mental models, morphological overview.

1. INTRODUCTION

Preservation of energy resources, occupant comfort and environmental impact limitation are the key issues of modern and sustainable architecture. Buildings use more than 40% of all our energy and generate emissions that polute the air and increases the effect of Global Warming [1]. Traditionally the architect has played the role of creator, making designs for the engineers to analyze, test, optimize and make buildable [2]. Due to the growing demands on efficiency, throughput time and quality, traditional approaches to organize and plan these building design processes may no longer suffice [3]. The conclusion is that buildings should no longer be designed by an architect alone: a whole design team is needed to cope with the complexity of the design problem and come up with new design solutions. During the building design processes, in order to reach the ever higher targets for sustainability and user comfort synergy between the different disciplines involved in the design process is necessary/essential. However the cooperation between the designers from different disciplines is especially in the conceptual design phase very difficult because of the cultural difference between creative architects (divergent thinkers) and analytic engineers (convergent thinkers) [4].

In conceptual design divergent thinking [5] is very important as it leads to spreading or branching, to a process that opens up many new directions. In design, this is what must happen during concept development. The ancient Greeks thought that there were devine sources that inspired creative work [6]. Creativity in the design is still often characterised by the occurance of the so called ‘creative leap’ [7]. However recent descriptive emperical studies of the creative event have shed more light on this mysterious and often mystified aspect of design [7]. There are many techniques, tools and methods developed to foster creativity. Hereby creativity was refered to by creativity reseachers as an attribute of a person [8]. In the past years the focus has moved to the group as a source of creativity and innovation [9]. Never the less huge ammounts of research still look for creativity in individuals. While more and more people look at teams, however this does not replaces the need to look at individuals as the are part of a team. This is the starting position for our research which focus on techniques stimulating building design teams’ creativity. Reseachers in several disciplines have applied the construct of mental models to understand how people perform tasks based on their knowledge, experience and expectation [9]. Shared mental models are dependent on the task demands and they should be carefully considered for every domain because of the difference in tasks and teams [10]. Therefore new types of models are needed to describe teamwork processes. Starting from the four models that are commonly used by Cannon-Bowers (the task model, the equipment model, the team

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model and the team interaction model) Badke-Schaub proposed a modified framework for design activities [10].

However the term team mental model is not meant to only refer to multiple levels or sets of shared knowledge but also to a synergetic functional aggregation of the teams mental functioning representing similarity, overlap and complementarity [11]. Therefore using mental model research to investigate design processes might help to understand how the solution finding creativity part evolves and how it is communicated in a team [9]. Designing typically takes part in an organizational context, with relations to clients and users and specific market situation. Thus, an analysis of mental models in design teams needs to include context knowledge that reflects the given situation [9]. Mental models are hypothetical constructs that cannot be directly measured [10]. Although there are a number of methods exist to indirectly measure these constructs we choose to focuss on one intervention and to use the tool of intervention also as a tool to measure and to represent a mental model of the team.

This research set out to develop a method to create a building design process that would create the opportunity to introduce a greater variety and amount of design knowledge from the outset of the conceptual design phase. Using workshops in which experienced professionals participated, a workable method was arrived at through iterative improvement of three of the key elements for conceptual design: design model, design tool and design setting. In Section 2 we describe our design process method and its tools in relation of the key types of mental models. In Section 3 we present the workshops and in session 4 some results of the workshops we applied to test our approach. In Section 5 there is a discussion and some conclusions followed by some limitations and future directions in Section 6. This paper is based on the work by Savanovic [12] and is extended in the direction of how to stimulate creativity in design teams by investigating the posssible use of mental models as a shared understanding within the design team about the interpretation of the design brief, the need to fulfil. The goal of the paper is to show that by applying a design method, Integral Design, with its use of morphological charts and morphological overviews, leads to the generation of more functions and aspects and subsolutions related to them.

2. METHODOLOGY: CREATIVITY AND DESIGN

2.1. Process

Pragmatic views of design as well as existing design theories define design as a (dynamic) mapping process between required functions and selected structures, however this dynamic mapping is not sufficient [13]. This functional mapping is also the underlying principle of Methodical Design developed by van den Kroonenberg [14]. Therefore we developed Methodical Design into Integral Design [12, 15] to allow addition of other design principles besides dynamic mapping.

The distinctive feature of the integral design method is the four-step pattern of activities (generating, synthesizing, selecting and shaping, see Figure 1), that occurs on each level of abstraction with the different phases of the design process.

After each step in the design process a decision is made to either proceed forward in the design process or go backwards by an iteration loop.

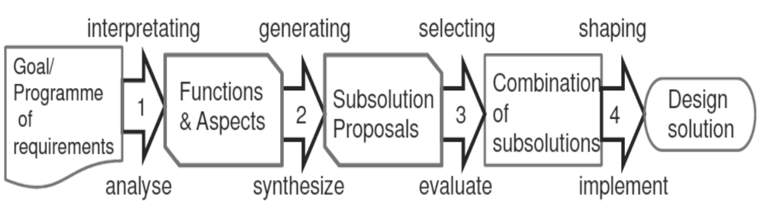

Figure 1. The four-step pattern of Integral Design with possible iteration loops [12].

2.2. Design tool

A distinguishing feature of Integral Design is the intensive use of morphological charts to support design activities in the design process. Morphological charts were first used by Zwicky [16]. 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, with related sub solutions listed on corresponding rows, see Figure 2. The functions and aspects are derived from the program of demands.

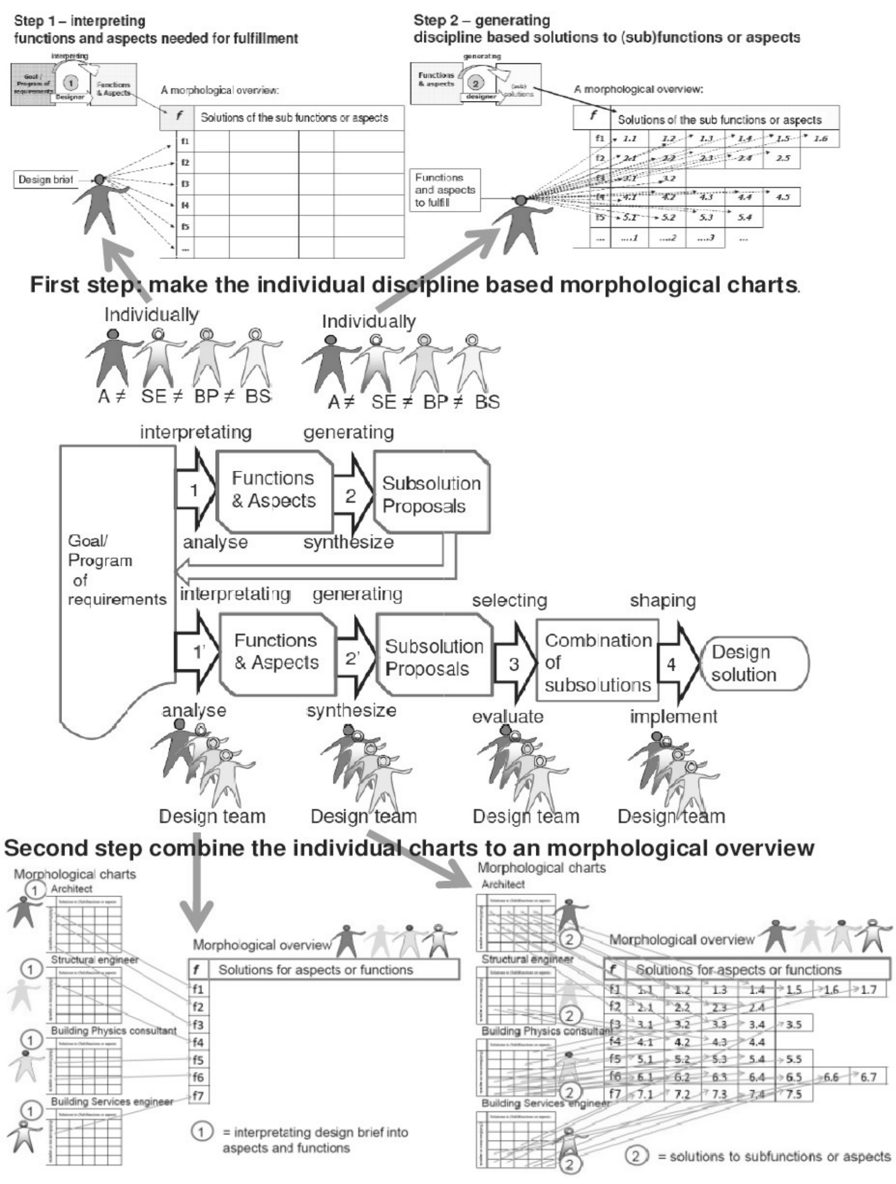

Figure 2. Integral design team process with its process steps.

The morphological charts made by each individual designer can be combined into a (team) morphological overview, after discussion on and the selection of functions and aspects considered important for the specific design. This is one of the most essential steps in the Integral Design process.

The team may complete the overview solely by transferring items from the charts into the overview. However, during this negotiation process the team may discover other options that did not originate from the charts, but from the discussion arising from them. As the overview becomes an essential reference text throughout the design process, not only does it keep the team focused on the recorded elements, those elements that need to be adjusted or replaced can be done so easily. The overview, it could be said, is often more than the sum of the parts. The numbered items in the overview represent proposed sub solutions, or in other words representations of object-design-knowledge, from one or another individual discipline. It may be the case that one discipline offers more than one sub solution for the given aspect, yet another discipline offers none. It may also be the case that some aspects have no recorded or workable sub solutions from any of the individual disciplines. Once the overview has been filled in, the design team can proceed in one of two ways. When possible, they could select the most desirable sub solution for each aspect and fit them into a final design proposal. However, arriving at the final design proposal on the basis of a first version of the overview is rarely possible. It is often necessary for the team to think past the knowledge that has been derived from the individual charts. When this is necessary the overview can act as the basis to stimulate the transformation of the recorded knowledge into new concepts.

3. EXPERIMENT: WORKSHOPS FOR PROFESSIONALS

3.1. Team and competence

The participants were members of the professional organizations of architects (BNA) and engineers (NLIngenieurs) in the Netherlands and had on average 12 years experience. In each workshops up to 7 teams, existing of an architect, structural engineer, building physics engineer and building service engineer, participated [12]. A total of 108 professional designers participated in the five workshop series, so an average we had 22 participants in a workshop series.

3.2. Context and design setting

In total 5 series of workshops were organized based on earlier experiments [12, 17]. After each workshop the set-up and the results were evaluated and adjustments made. The experiences of the first three workshops ‘learning by doing’ series led to a final set-up for the workshops which was used both for series 4 and 5. During workshops series 4 and 5 the teams were changed after each session in such a way that none of the participants work more than once with each other. Essential element of the workshop were besides some introduction lectures the design cases on which the teams of designers had to work and which they had to present at the end of each session to the whole group. These were tested in earlier workshops and were identical in the workshops series 4 and 5. In the final workshops series configuration of sessions, stepwise changes to the traditional building design process type, in which the architect starts the process and designers of other disciplines join in later in the process, are introduced in the set-up of the design sessions, Figure 3.

The process of combining the knowledge from the morphological charts into an morphological overview is negotiated within the design team in session 3 and session 4. Design session 3 represents a learning-by-doing opportunity for the individual disciplines and the design teams. The ideal outcome would be that each team could clearly demonstrate successful use of the design tools during the design process. However, as a key part of learning is feedback, after the teams completed tasks set in session 3, time was given to compare and appraise the teams work and to answer any questions that arose.

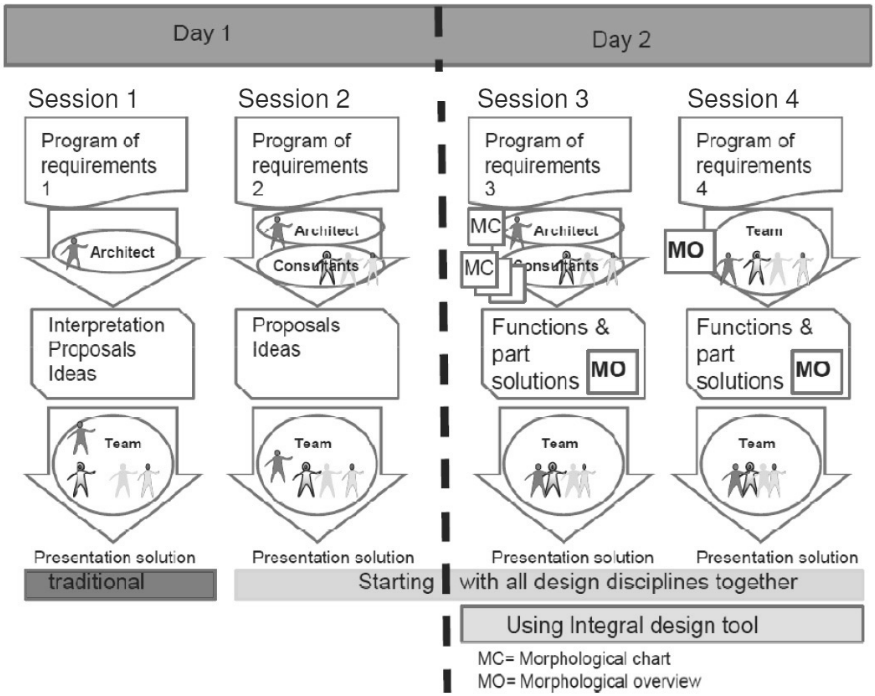

Figure 3. Workshops series 4 & 5: four design sessions each with its own different design set-up of tool and participants [12].

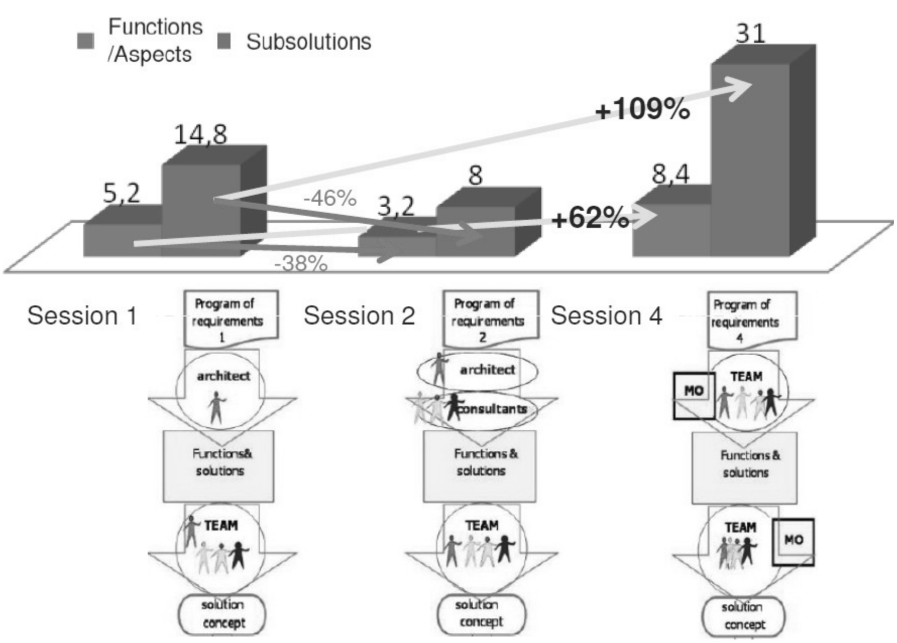

Figure 4. Comparison of the average amount of aspects/functions and the average number of partial solutions being generated by the design teams in design session 1, 2 & 4 [12].

4. RESULTS OF THE WORKSHOP

In the analysis we focus on the first two steps of the Integral Design process: generation of need/function and synthesizing from need/functions to possible solutions. Here we show the results of the final workshops series, see Figure 4. The results of sessions 3 are not presented, as this session was meant as a learning session for the tool. After feedback on the tools in session 3 the designers used the tool in a correct way in session 4. As we are interested primarily in the effect of the design tool is only correct to make the comparison between session 1, 2 and 4. Here only a brief selection of all the results is given. More results and information is presented by Savanovic [12]. The comparison of design sessions 1 and 2 presents the effect of introducing all the different designers from the start without using support. This led to a decrease of the number of aspects and subsolutions, indicating a less effective design process.

5. DISCUSSION AND CONCLUSIONS

We presented the results of 6 teams with in total 24 professionals. Though this might be a rather low number of experiments, the repetition of the experiment of workshops series 4 in workshops series 5 increased the validity of the outcome and conclusions. Theoretical you want to have more experiments and more participants but in reality this is not possible and we were glad with the number of participants that we had.

From the analysis of the workshops it could be concluded that the solution space, resulting from the number of functions and aspects considered, was significantly increased by applying the Morphological Overviews. A good example of this increase can be seen from the results from session 1 [without morphological charts and morphological overview] compared with the results of session 4 [with use of morphological charts and morphological overview]. Figure 4 shows that, as expected, more aspects and sub solutions were generated in setting 4 than in the previous sessions 1 and 2. The increase of the number of considered functions and aspects leads to a larger number of partial solutions, which implies an increased problem-solution space.

As can be seen from Figure 4 the application of the design tool increases the average amount of functions/aspects as well a the amount of generated subsolutions. The effect of starting from the very first moment in a building design process with all involved designers from different disciplines leads to a decrease in the amount of generated functions/aspecs as well as the amount of subsolutions. The differences are significant. As such the conclusion therefore is that the design method stimulates the generation of solutions by the multi disciplinary building design teams.

Based on the applied Integral Design method to structure the design process and using its design tools, the morphological chart and morphological overview we can show in analogy with the model of Badke-Schaub [9], how the mental models in teams develop. Based on the current situation, each design team member, architect, structural engineer, building physics consultant and building services engineer, perceives reality due to his/her active perception, memory, prior knowledge and needs, see Figure 5. It shows that the morphological charts and morphological overview of the Integral Design method can make transparent some parts of the Team Mental Model.

The activation of design team member's knowledge through a priming manipulation such as the use of morphological charts of morphological overviews leads to the generation of possibly generation of more (original) solutions. However, there is an uncertain relation between quantity and qualilty. The most parsimonious interpretation of the quantity-quality relation is chance [18]: each generated idea has an equal probability of being a good idea. Therefore, according to the laws of chance, the number of good ideas producced should increase in dependency of the total number of ideas produceed [18]. Still there is no simple linear relation between total productivity and the number of good ideas. An alternative view is proposed by Rietzschel [18], which states that creative idea generation is enhanced by deep exploration of relevant domain knowledge, and that generating more ideas within a particular subcategory of the overall problem should be associated with a higher originality of those. This view fits to the application of Morphological Charts as an overview of the specific domain knowledge. The degree to which individual designers undertake deep exploration of a particular function or aspects fromout their domain is an mechnism to stimulate the process and to focus on quality. That would

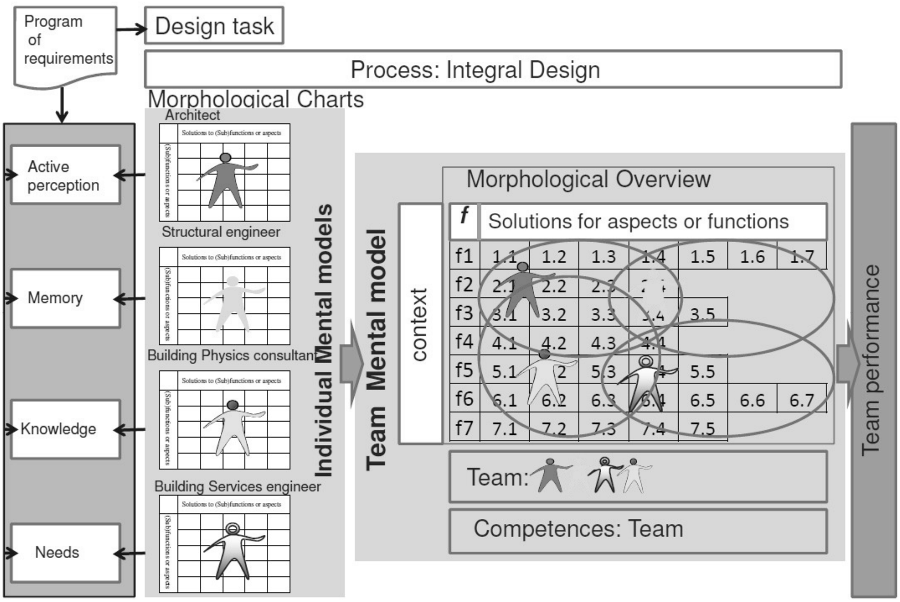

Figure 5. Design Team mental model in analogy with the model by Badke-Schaub [9].

mean a important step to added value of the combination of design & creativity in the building design process.

6. LIMITATIONS AND FUTURE DIRECTIONS

To have control over the onset, frequency, and length of design sessions, we simulated conceptual design sessions in a workshop setting. Although this setting is as close as we can get to a normal

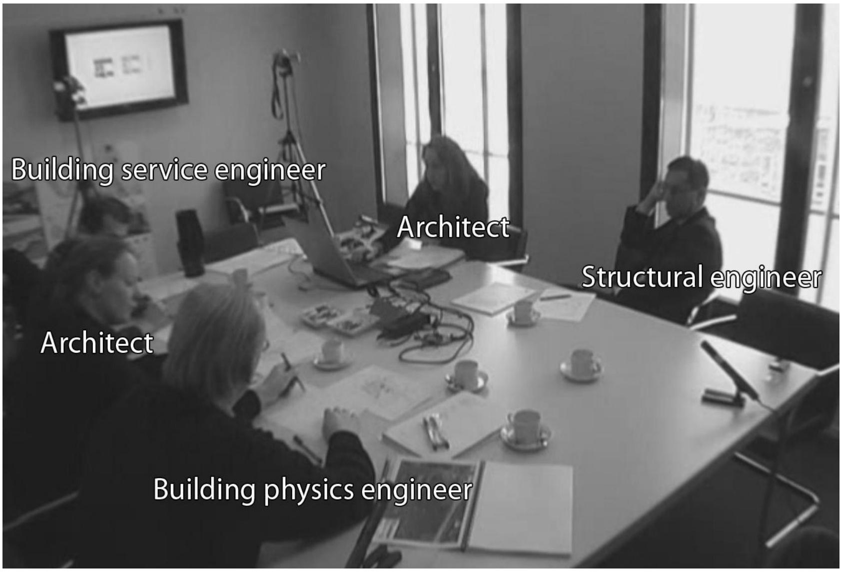

Figure 6. Real design session in preparation to a design competition presentation.

working situation there are ofcourse some fundamental differences. The workshops has a kind of study course atmosphere with instructional presentations and excercises for the participants. However, the participants grow very fast in their role-play and seem to play it for real. However, the design tasks based on real projects are of course no real projects, so financial aspects or legal aspects of contracts are no issue as opposed to real practice. To get even more close to real practice we intend to observe and analyze design contest meetings, in which design teams prepare a conceptual design for a design competition. We were already able to video tape such a session, see Figure 6.

The session took two houres, so the same as in our workshop setting, and had the same design disciplines participating as our workshop sessions: architect, structural engineer, building physics consultant and building services engineer. However much of the time the team spent on financial aspects, discussion about the budget, and some legal aspects of the contract. So these aspects definetly have to be included in further research.

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