Morphological Analysis of Design Sessions

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Abstract: There is no consensus within the design research community on how to analyse design meetings. In contrast to models which conceive designing as a strict goal-directed process, we think at an interpretative approach suggesting a methodical reorientation. We were interested in exploring whether previously neglected design methods can be adopted for use as analytic tools for design meetings. Specific tools for this purpose are morphological charts and morphological overviews. Based on the definition of design by the C-K theory, we have used morphological overviews to reconstruct the emergence of design concepts in architectural meetings. This was done by analyzing video recordings of these meetings.

Our results show that morphological charts are useful for the analysis of design meetings as they were being capable of presenting the development of design concepts. Morphological charts proved to be effective in reducing the time needed to analyze a rich set of data. We believe this complexity reduction offers the possibility of doing research on more (complex) design meetings more effectively, which is beneficial for generalization of findings.

Keywords: morphological charts, design meetings, design concepts, design research method

1. Introduction

Traditionally the design process in the built environment starts with a principal/ client who want to have a new building. The principal approaches different architects and after the selection by the client the chosen architect starts to work with the client to find out what is needed. The architect immediately starts thinking of a solution to the needs of the client although the design brief is not clear enough. From that moment on he mainly can make combinations and variations around that first idea and as a result his possible solution space is restricted, see Fig. 1a [1]. Further more his solution space is restricted by boundaries resulting from fictitious restrictions, boundaries from his limited knowledge and of course boundaries from genuine restrictions, see Fig.1b. If we look on how this traditional design approach is changing when the other building designers such as building services engineers, structural engineers and building physics engineers join the architect is seen in Fig. 1c to 1f. First we start with the knowledge related solution space of the architect (Fig. 1c) than the other design team members join in (Fig.1d). Instead of focusing around one solution, different options from different disciplines are proposed (Fig. 1e), which leads to new interactions and new possible solutions (Fig. 1f). The solution space of the design team is clearly bigger than above that of the architect alone.
Still we want to verify this seeming logical explanation in design meetings. There are many ways and many
different possible tools to analyze design meetings [2, 3] However, before deciding upon which tool (not) to use,
or to introduce a whole new approach, we think it is first necessary to decide upon exactly what should be the
focus of the analysis.
We will therefore first explain the theoretical background of our approach in section 2. Then the application of
this approach will be described in section 3. This description is followed by the results and discussion of the
outcomes in section 4. Finally, conclusions and remarks on future research will be given in section 5.

2. Methodology
In the past a number of prescriptive design methods were developed, these were largely based on the view of
design as an ill-structured problem solving activity [4]. Even though design undoubtedly includes stretches of
‘normal’ ill-structured problem solving [5] any model or description method that tries to reduce design to ill-
structured problem solving is bound to miss important aspects of the design activity [6]. Recognizing the fact
that design is not a scientific or merely a problem solving activity, we wondered if any of the existing and largely
neglected prescriptive design methods could help us to understand design by using them for research, rather than
(as originally intended) for design activities. The motivation behind this idea was that, being developed on basis
of scientific approach to designing, these prescriptive design methods ‘automatically’ meet the requirement for
being methodical – one of the key characteristics of valid design research [7].
Starting from the prescriptive model of Methodical design [8], 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 [9]: 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 [10].

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 [11]. By using morphological charts each discipline can look for all the necessary functions and aspects decomposed from the program of demands. All the design team members have 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. 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 Fig. 2.

![Diagram of Morphological Overview](image)

Figure 2: 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 2, 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.

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 [12].

Assuming that design thinking is related to design knowledge, and that knowledge is often something implicit, the definition of design by C-K theory [12,13,14,15] allowed us to approach design concepts as indicators of design thinking. The following is a brief summary of the core elements from Hatchuel’s and Weil’s theory.

The C-K theory defines design as the interplay between two interdependent spaces having different structures and logics. This process generates co-expansion of two spaces, space of concepts C and space of knowledge K. Proposed as a unified design theory, C-K theory focuses on innovative design [14]. However, the majority of cases in design do indeed concern mere computation, optimization and/or combinatory, which we would also like to capture as the possible outcomes of design meetings. Therefore, we propose the distinction between ‘integral design concepts’ (ID) and ‘redesigns’ (RE) [15]. The lower part of Fig. 3a represents the model of new object design knowledge (nODK) development within a design team configuration. Based on all the above, the focus of our analysis was to investigate the expansion of the solution space by the emergence of ‘integral design concepts’ (IDC) during design meetings, see Fig. 3b.

![Figure 3: Solution space new object design knowledge (nODK) and possible expansion of the solution space by Integral Design Concepts (IDC) as result of expansion from space K to space C.](image)

### 2.1 Application of the research approach

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 [13].
- **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" [13].

The transformations within and between the concept and knowledge spaces are accomplished by the application of four operators [15]: 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” [17], 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 (Fig. 4). Only explicitly communicated object design knowledge within a design team is considered and the focus is on how this explicit object design knowledge is transformed within a multidisciplinary 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 Fig.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 Fig.4. Concepts acquired through transformation of iODK into ID, see step 3’ in Fig. 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 IDC, 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 Fig.4 step 4’ - evaluating [activities]. The focus is on the possibility of expanding the concept space with integral design concepts (step 3’- Fig. 4, IDC), in order to produce potential for creation of new object design knowledge (step 4’- Fig. 4, nODK).

![Diagram](image_url)

**Figure 4: C-K Design process scheme**

### 2.2 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, started now from a group perspective based on which the individual designer can make the decision to whether or not make an explicit contribution from his own morphological chart (see Fig. 5, symbol 2). Since the object of design is used as the reference, this knowledge is further specified as initial object design knowledge (Fig. 5, symbol 2). From these contributions new combinations can occur, (Fig. 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 (Fig.5, symbol 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 Fig. 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 Fig.5 the connection between the C-K theory of Hatchuel and Weil and the morphological approach of the integral design method is presented.

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.
3. Experiments: Workshops for Professionals (architects and consulting engineers)

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.

3.1 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 [18] 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 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 (Fig. 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 allowed simultaneous involvement of all design disciplines on a design task, aimed to influence the amount of considered design functions/aspects. Additional application of morphological overviews during the set up of the third design session demonstrated the effect of transparent structuring of design functions/aspects on the amount of generated (sub) solution proposals. Additionally, the third setting provided the possibility of one full learning cycle regarding the use of morphological overviews. All sessions were put on video tape and additionally photographs were taken every ten minutes. The end presentations and all used material, sketches etc. were also photographed.
Concerning the results of our approach we looked into the extension of the solution space and the analysis possibilities of the design process through morphological overviews. To conclude this section comparison is made between settings 1 and 4 of the final workshop 5. Fig. 7 shows the number of aspects and sub solutions generated by the teams in the two different settings 1 and 4, this clearly shows that, as expected, more aspects and sub solutions were generated in setting 4 compared to setting 1.

**4. Results**

In the analysis that we present here we focus on the first two steps of the Integral Design process: the generation of need/function and step 2 synthesizing from need/functions to possible solutions. Here we show the results session 3 of the workshops held in 2007. Fig.8 gives the results of morphological charts and the design team session.
Figure 8: Morphological charts and morphological overview of group 2 to 5 of the workshops series 2007.

From Fig. 8 it shows that all teams used the morphological charts to produce their morphological overview and 3 out 4 teams even used their morphological overview to present their final design. More important is that we now have a possibility to look into more detail into the design process. As an example we give the results from the workshop 2007, session 3, groups 2 to 5 step 1 of the Integral design method: the generation of functions and aspects from the design brief, see Fig. 9.

Figure 9: Morphological representation of step 1 generation of functions and aspects with the Integral Design process
Immediately one can see that all groups had a different outcome of the process. In group 3 the architect remained dominant and no extension of the design space took place, no aspects or functions were added. In group 5 there is a little input from the building physics consultant, but still the architect is here also dominant. In group 2 something strange occurred as the design team made their own interpretation of the morphological overview and started from that interpretation the process. Only in group 4 there the interaction between the different design disciplines leading to a clear picture of the expansion of the design space as beside the 2 functions/aspects of the architect there are 2 functions/aspects added by the building physics consultant and 4 from the building service consultant.

5. Conclusions
The results show that the approach we chose was successful. The morphological overviews proved to provide a simple yet powerful support for the analysis of design meetings. Besides being capable of presenting the development of design concepts, morphological charts were very effective in reducing the complexity of the rich research data, while maintaining enough accuracy for the intended analysis. They offered the possibility for selective examination of those aspects considered important, in our case the explicit object-design representations. The reduction of data complexity will increase clarity if more complex meetings are analyzed. Through this reduction of complexity the use of morphological charts can be a good alternative to the time-consuming protocol analysis approach. Although we know how difficult it is to gather this type of design data, the ‘choice’ for the discussed meetings in this paper is a good example in itself, our recommendation for future research on the use of morphological charts/overviews would be to analyze more and different design meetings.

In addition to investigating if morphological charts, originally a design method, could be used as a research tool, the aim of our analysis was to contribute to the field of design research by proposing ‘integral design concepts’ (ID) as indicators for design thinking and creativity, and showing how their emergence can be established.

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References


