

# THE POSITIVE EFFECT OF A MORPHOLOGICAL APPROACH ON DESIGN TEAM COOPERATION

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## ABSTRACT

The increasing complexity of design makes it necessary to consider different ways to design projects. In connection with the Integral design research project for professional in the Dutch building industry, we developed an educational project, the master project integral design. Interaction between practice, research and education forms the core of the 'integral approach'. Therefore the concept of the integral design workshop for professionals was implemented within the start-up workshop of our multidisciplinary masters' project. The basis of this project, which serves as a learning-by-doing start-up workshop for master students, is the Integral Design method with its use of morphological overviews. The different design assignment all were related to the design of zero energy buildings. These complex tasks require early collaboration of all design disciplines involved in the conceptual building design. Master students from architecture, building physics, building services, building technology and structural engineering participated in these projects. The master project Integral design was initiated by the chair of Building Services in the 2005/06 academic year and since then was held every year. The master students from architecture, building physics, building services, building technology and structural engineering were offered the opportunity to participate. The frame work of the approach will be described as well as the positive effect on the collaboration between the design team's members as result of the morphological frame work.

*Keywords: Morphological chart, integral approach, integrated design, multi-disciplinary project.*

## 1 INTRODUCTION

The increasing complexity of design makes it necessary to consider different ways to design projects and more requirements are made on the operation of the product, with minimal energy depletion and environmental pollution. This also makes it necessary to strive for optimal integration between the disciplines in order to achieve the goal of making a good product that is optimized throughout its life cycle. Increasingly, the need is felt on a daily basis to achieve early integration of disciplines and parties. Such early interaction is only possible on the basis of mutual trust and respect for everyone's input. The interaction with other disciplines and stakeholders in the conceptual design phase has to change. More the traditional hierarchical relationships will need to be improved and made more interactive.

One of the complicating aspects in building practice is the different cultural backgrounds of architects and engineers and their different approaches to design [1]. As a result miscommunication occurs caused by not speaking a common language. Communication between the various disciplines involved in the design of complex technical products or systems makes it difficult to communicate across disciplinary boundaries, even though the scientific methods that are used have similarities in approach, regardless of the discipline itself. Integrated design is a topic which has been discussed for years. Everyone sees the advantages of integrated design, but in practice, the actual introduction is very slow. In practice, it is more difficult to make individuals and organizations work together. The main cause is that the people and organizations are from different disciplines.

## 2 METHODOLOGY

In building design, one has to work with ill-defined design problems where the solution and the problem itself develop almost in parallel at the early stages of the design process. A good project start-

up is important: the meeting at the beginning of the project, where you get to know each other, understand and agree upon the goals of the project are. There are techniques to ensure that a new team starts in a good way. Usually a team goes through four phases before it is really tuned to each other. Tuckman [2] has described the development of cooperation within groups. Groups develop themselves in a certain order into a team: forming, storming, norming, performing and adjourning. It is a good model (see Fig. 1) for the promotion of cooperation within a team [3], which can be used to illustrate the steps of morphological approach (see Fig. 2):

- Framing (Orientation Phase) - There is no team spirit yet. Individual positions and roles are not taken yet. Group members take a cautious approach and are in need of guidance. In this first phase, the 'forming' phase, you get to know your teammates and there is an enthusiasm about the new project. A lot of pace is created. Other Features; hesitant participants, do I belong or not, polite communication, concerns about the group's goals, an active leader and pliant members.
- Storming (Power Phase) - In this phase, the group members trying to take their position in the group. This process often leads to conflict when people have different ideas. In the second phase, the 'storming' phase, you discover that there is difference of opinion in some respects and that not all the tasks and responsibilities fit very well with each other. The enthusiasm dies down and the team is less effective. Other features of this phase; critique on ideas, moderate focus, hostility, polarization and coalition forming.
- Norming (Affection/standardization phase) - Group members come closer together. The rules and methods of cooperation are determined. The common team goals are shared and determined. The emergence of a more mature manner of working together. In this phase, there is a realization that you have make mutual agreements in order to work properly. This happens and the team will start to perform better. Other features: making agreements, decrease of confusion about the roles and an increased 'us' feeling.
- Performing (Performance Phase) – In this phase there really is a solid team. Team members complement each other and work together harmoniously to a common team goal. The team is able to work independently. In this phase, the team members become better attuned to one another and there is more and more progress. Other features: decision-oriented, solution-oriented, mutual cooperation and production oriented
- Adjourning (Goodbye Phase) - This team is eliminated, the design task has been carried out. Features of the phase: dissolution, withdrawal and increased independence.

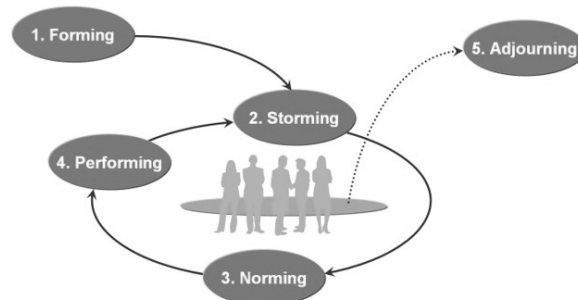


Figure 1. The various stages of team development [3]

In addition, the amount of relationships and dynamic social interactions makes design increasingly complex. Therefore, a method is needed to structure would-be design solutions. In the early 1960s researchers and practitioners began to investigate new design methods as a way to improve the outcome of design processes. Since then, there has been a period of expansion through the 1990s right up to the present day. However, there is still no clear picture of the essence of the design process and many models of designing exist. After studying different design methods, it was decided to use a method derived from the General System theory [4]. This methodical design method has as a distinctive feature the step pattern of activities (generating, synthesizing, selecting and shaping that occurs within the design process. The methodical design method was expanded to a multi-disciplinary design method, Integral Design, through the intensified use of morphological charts developed by Zwicky [7]. This to support design team's activities in the conceptual building design process [5, 6] and especially the use of a morphological overview built from the individual design team member's morphological charts. A morphological chart is a kind of matrix with a first columns which contains the aspects and functions to be fulfilled and rows with the possible sub-solutions connected to them.

So in the first step of the integral design method the individual designer has to make a list of what he thinks, based on his own specialist perspective, are the most important functions or aspects that have to be fulfilled in relation to the design brief. This is then put into the first column of the morphological chart. In the second step of the process, the designers add the possible part solutions to the related rows of the functions/aspects of the first column.

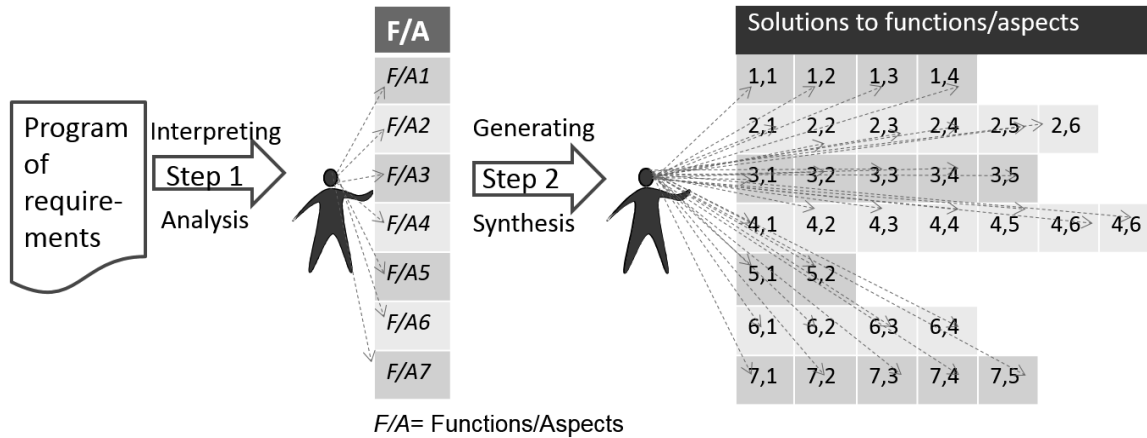


Figure 2. The first two design steps of the design process cycle, interpreting the design brief and list the functions in the first column of the morphological chart and add the related sub-solutions

Individual morphological charts can be combined by the design team to form one morphological overview, see Fig. 3. Putting the morphological charts together enables ‘the individual perspectives from each discipline to be put on the table’, which in turn highlights the implications of design choices for each discipline. This approach supports and stimulates the discussion on and the selection of functions and aspects of importance for the specific design task.

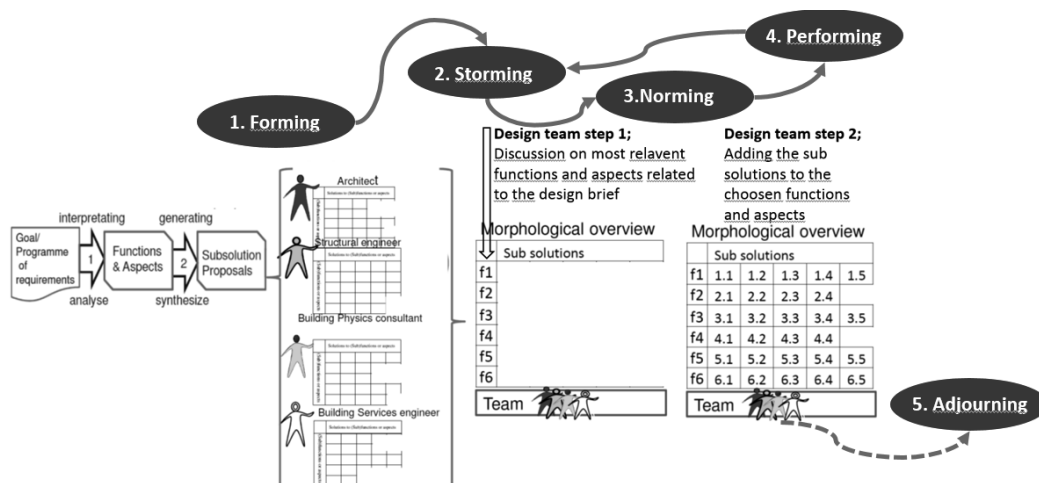


Figure 3. The second phase generating the morphological overview

### 3 INTEGRAL DESIGN: WORKSHOPS LEARNING BY DOING EDUCATION STARTING IN INDUSTRY

Since 2000 together with the Dutch Royal society of architects (BNA), the Dutch Association of Consulting Engineers (ONRI), the Dutch Society of Building Services Engineers (TVVL) and different Roofer associations in total 14 series of workshops were organized in which in total more than two hundred experienced professionals, with at least 10 years experience, from these organizations, voluntarily participated. After extensive experiments with different set ups for implementing the Integral Design approach, in which well over one hundred professionals participated, it was concluded that a good way to test our design approach was a workshop setting for professionals. Therefore workshops were arranged as part of a training program for architects and consulting engineers (structural engineers, building services engineers and building physics engineers) [6]. These design exercises were derived from real practice projects and as such were as close to

professional practice as possible. The design tasks during the two days are on the same level of complexity and have been used in all workshops. In the workshops stepwise changes to the traditional building design process type, in which the architect starts the process and the other designers join in later in the process, were introduced in the set up of the design sessions. In the final series of the research focussing on the interaction between architects and engineers during the conceptual design phase three different design set ups of participants were tested in four sessions [6].

In connection with the Integral design research project for professional in the Dutch building industry, we developed an educational project, the master project integral design. Interaction between practice, research and education forms the core of the ‘integral approach’. Therefore the concept of the integral design workshop for professionals was implemented within the start-up workshop of our multidisciplinary masters’ project. The basis of this project, which serves as a learning-by-doing start-up workshop for master students, is the Integral Design method with its use of morphological overviews. The different design assignment all were related to the design of zero energy buildings. These complex tasks require early collaboration of all design disciplines involved in the conceptual building design. Master students from architecture, building physics, building services, building technology and structural engineering participated in these projects. The master project Integral design was initiated by the chair of Building Services in the 2005/06 academic year and since then was held every year. The master students from architecture, building physics, building services, building technology and structural engineering were offered the opportunity to participate. The specific aspects of the office building design assignments were to realise ‘sustainable comfort’, a net Zero Energy Solution on different locations. Bearing in mind that in the current situation, 40% of primary energy consumption is due to build environment such a task is highly complex. It requires early collaboration of all design disciplines involved in the conceptual building design.

#### 4 THE RESULTS OF THE WORKSHOPS: THE POSITIVE EFFECT OF A MORPHOLOGICAL APPROACH

Central element of the Integral Design process is the use of morphological charts by individual designers which were combined into one morphological overview by the design team. The design teams existed in principle of 4 students from different disciplines. In total around 170 students participated in the research. In a startup workshop the students had to practice with the same exercise during all the years which made the outcome comparable. This was the same exercise as had been used during the research with professionals. The number of functions and sub-solutions mentioned by the designers in their morphological charts were counted and the average numbers of functions and solutions as mentioned by the design teams are represented in Fig. 4. The same was done for the sub-solutions mentioned by the design teams in their morphological overviews.

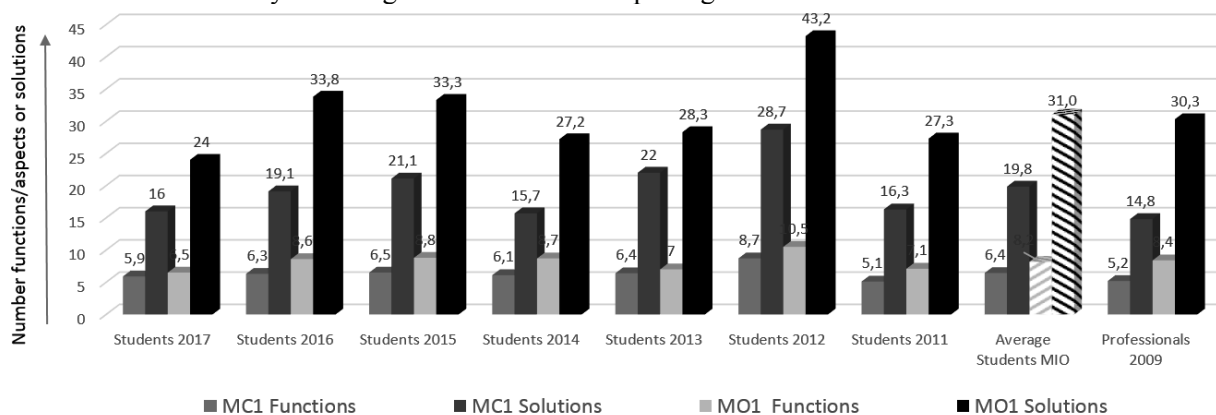


Figure 4. Average results workshops Integral Design for students compared with that of professionals from the research by Savanovic [6]

Here only a brief selection is given of all the results and a comparison with the professional workshops Integral Design. More results and information were presented by Savanovic [6]. Compared with the results of professionals the students generated on average more functions/aspects as well as sub-solutions than the professionals in their morphological charts. There was however no significant difference between students and professionals in their morphological overviews. There was a clear increase in the number of mentioned functions (+62%) as well as the number of mentioned sub-

solutions (+105%) in the workshops for professionals as well as in the workshops for students functions (+28%) and sub-solutions (+57%) (see Fig. 4). In both cases there was a positive effect: an increase of number of functions/aspects and sub-solutions mentioned by the team's morphological overview compared to the numbers of the individual morphological charts. However, there were also a few teams where one of the individual design team members had more functions/aspects mentioned than were taken over in the morphological overview, but these were exceptions. As can be seen from figure 5 there are large individual differences in outcome between the designers in functions/aspects (min. 3 max. 14 average 6.5) as well as between the design teams (min. 4 max. 16 average 8.2), as well as in sub-solutions (min. 4 max. 52 average 20) individual designers and (min. 12 max. 71 average 31.3) for design teams. So clearly the difference between the individual designers has a large effect on the absolute outcome of the process. However, in almost all cases (around 95%) the quantity outcome of the design team is higher than that of the individual designers and especially the design team's discussion will improve the quality of the mentioned functions/aspects and sub-solutions.

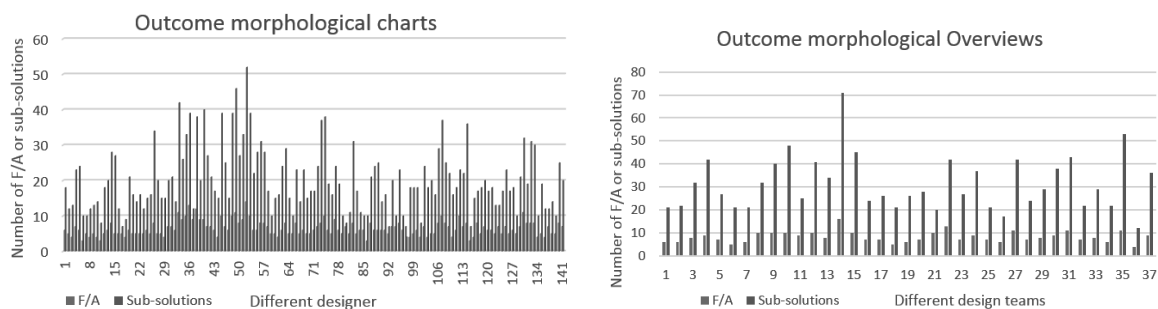


Figure 5. Comparison of the outcome of individual designers and different design teams

When comparing the trendlines in the number of sub-solutions versus functions/aspects in morphological charts and morphological overviews, it shows that in the charts there is a relation of 3.8 sub-solutions per function/aspect whereas in the morphological overviews this is 4.4 sub-solution per function/aspect. Clearly the design team's interaction accounts for more results.

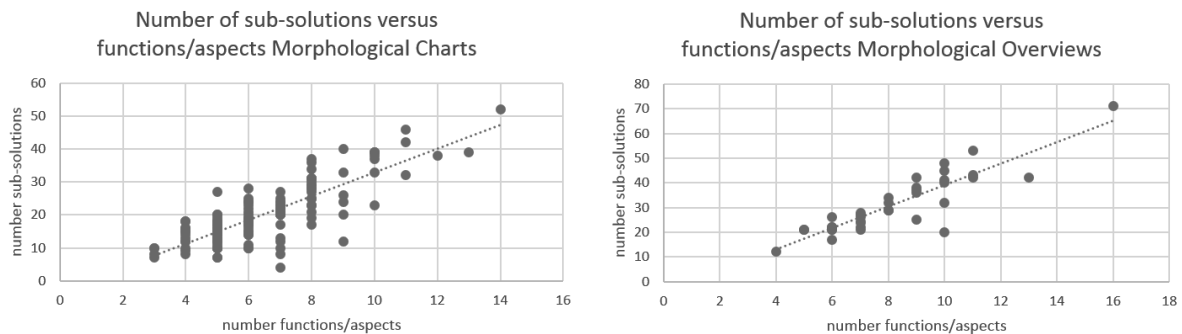


Figure 6. Relation between number of mentioned functions/aspects and number of sub-solutions mentioned in the morphological charts and morphological overviews.

## 5 DISCUSSION

Given the existing disparities in the construction industry, King [8] stated that in order to do anything meaningful in terms of moving to a low carbon society, there is a need for a consistent framework within which knowledge can be applied as embodied in a design team. By structuring the interactions of designers from different disciplines in the conceptual phase of building design, it is possible to support members of every discipline to handle tasks and to supply information from other disciplines. The Integral Design methodology was tested through workshops with industry professionals from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (NLIngenieurs). After this it was implemented in the educational program of the university.

Putting the morphological charts together makes it possible to 'put on the table' the individual perspectives from each discipline about the interpretation of the design brief and its implications for each discipline. This enables, support and stimulates discussion on the selection of functions and aspects of importance for the specific design. In step two the functions and aspects are discussed and

decisions are placed by the team in the morphological overview. Structuring design (activities) with morphological overviews as the basis for reflection on the design results stimulates the communication between design team members. Thus integral design helps the understanding within design teams and stimulates collaboration to come forward with new design propositions. Through visualizing the individual contributions within a design team, morphological overviews based on the individual morphological charts stimulate the understanding of different perspectives within design teams.

The data presented is only based on the number of mentioned functions/aspects and sub-solutions. However you could ask is more always better? In the morphological charts there was no checking on the quality or whether they were realistic. In the morphological overview only those functions/aspects and sub-solutions were included which were accepted after the discussion within the design team. So therefore the quality of those mentioned functions/aspects and sub-solutions will be higher and more realistic. So normally this would lead to a decrease in numbers. This indicated not only a gain in quantity but also in quality and relevance in relation to the mentioned functions/aspects and sub-solutions of the morphological overview.

Workshops are a self-evident way of work for designers that occur both in the practice and during their education. There are a number of advantages workshops have with regard to standard office work, while at the same time retaining practice-like situation as much as possible: the possibility to gather a large number of designers in a relatively short time, manipulation of design team formation, repetition of the same assignment and comparison of different design teams and their results. The suitability of workshops for integration of design team activities, together with suitability of morphological overviews for structuring knowledge of design team members, forms the basis on which the education design method is built.

Our presented approach of combining research for education for students based on experience with professionals is quite unique. Interaction between the practice, research and education forms the core of our integral approach; we implemented the same workshop pattern and methodology within our multidisciplinary masters' project at the university.

## 6 CONCLUSIONS

The workshops and the multidisciplinary projects provided us with many insights, some of which were discussed in this paper. Building design processes can be improved through improving process communication understanding, sharing and collaboration. Tuckman has described the development of cooperation within groups. Groups develop themselves in a certain order into a team: forming, storming, norming, performing and adjourning. It is a good model for the analyzing the steps within the development of cooperation within a team and can be used to illustrate the steps of morphological approach. The use of the morphological chart is an excellent way to record information about the solutions for the relevant functions and aid the cognitive process of understanding, sharing and collaboration.

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