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MORPHOLOGICAL OVERVIEW IN INTEGRAL BUILDING DESIGN: PRESCRIPTIVE REFLECTION

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ABSTRACT:

Building Design involves multi-disciplinary design teams and integrates contributions from different disciplines: architecture, construction, building physics and building services. It involves intense information exchange between participants within the design process. To support this highly complex process an Integral Design method is developed by combining a prescriptive approach, Methodical Design, with a descriptive approach, Reflective practice. Based on the Methodical Design approach by van den Kroonenberg, a more reflective approach is developed. The use of Integral Design within the design process results in transparency of the design steps and the design decisions. Within the design process, the prescriptive methodology of Integral Design is used as a framework for reflection on the design process itself. To ensure good information exchange between different disciplines during the conceptual phase of design a functional structuring technique can be used: Morphological Overviews (MO). Morphology provides a structure to give an overview of the functions considered and their alternative solutions. This method is presumed to help to structure the communication between design team members, and form a basis for reflection on the design results by the design team members. This method is used in an education program at the Technische Universiteit Eindhoven and was tested in

workshops for students and for professionals from the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (ONRI). Over 250 professionals participated in these workshops

1. INTRODUCTION

As the complexity and the scale of design processes increased together with rising demands on these processes in terms of costs, throughput time and quality, traditional approaches to organizing and planning these processes were no longer sufficient (van Aken 2003). There is the need for better design processes and so for research in the field of design. Design research can be relevant for practice only if it recognizs 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 & Dorst 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 (Schön 1983, Buccialli 1994, Rozenburg & Drost 1998) and can only provide a framework for the description and explanation of the context-dependencies of designing (Drost & Hendriks 2000). At the moment there is a gap between theory and practice as a result of overlooking the context of the design process itself. Models are needed to make the translation between the worlds of Design Methodology and Reflective Practice, and to look at designing as a process in which the concepts of function, behavior and structure of artifacts play a central role (van den Kroonenberg & Siers 1992). We believe that this is the reason why the design research community is showing renewed interest in models of design as a process.

The main problem of research on Design Methodology is the double aim of describing actual design and prescribing improved design (Vermaes & Drost 2007). Still we believe connecting descriptive and prescriptive modeling is an important step to solving the problem. We think that creative design is often not a matter of first fixing the problem and then searching for a satisfactory solution. Instead, it seems more a matter of developing and refining both the formulation of the problem and the articulation of its solution, with constant iteration in analysis, synthesis and evaluation that move between the ‘problem space’ and the ‘solution space’ (Dorst & Hendriks 2000).

Starting from the prescriptive model of Methodical design , we developed a way to articulate the relationship between rational problem solving and reflection in action. The resulting design matrix represents the process in a very condensed way, and allows the designer to select which phases

or elements of the design to focus on. Preliminary tests of the methodology have been conducted through workshops with industry professionals.

2. Methodology: Methodical Design

In the early nineteen seventies in the Netherlands a methodology was developed to teach design to mechanical engineers at the Faculty of Mechanical Engineering Technical University Twente at Enschede: the Methodical design model from van den Kroonenberg. Several course books were written and articles published in Dutch professional periodicals. From the start Methodical Design facilitated teaching and transfer of design methods to industry. The Dutch Royal Society of Engineers, Kivi, had its own course for professionals in 1974. It is a model with typical and exceptional characteristics (Blessing 1994):

- it is a problem-oriented model
- it is the only model that emphasizes the execution of the process at every level of complexity
- it is one of the few models that explicitly distinguishes between strategies, stages and activities

Methodical Design is problem-oriented and distinguishes, based on functional hierarchy, various abstractions or complexity levels during different design phase activities. Methodical Design makes it possible to link these levels of abstraction with the phases in the design process itself. Methodical Design is based on a combination of the German design school and the Anglo-American school (Blessing 1994).

2. 1 EXTENDING OF METHODICAL DESIGN TO INTEGRAL DESIGN

Though the Methodical Design model is one out of a great variety of design models it is the only method to make a distinction between phases and levels (Blessing 1994). The three main phases which are distinguished are: defining the problem, determining the working principle and detailing the design. The levels are a distinction based on a hierarchy of complexity. The design phases and complexity levels form the main elements of the structure or framework of methodical design (de Boer 1989).

Based on the design matrix presented by Van den Kroonenberg (1978) and by DeBoer (1989), an extended design model was constructed: the integral design matrix. In the integral design matrix the cycle (define/analyse, generate/synthesize, evaluate/select, implement/shape) forms an integral part of the sequence of design activities that take place. The integral design matrix

provides the overall structure that makes the basic design steps recognizable as such. The method/contents matrix represents the recursion of the steps of a design process from high abstraction level to lower abstraction levels. These steps result in a complete framework of connected levels of complexity or abstraction. The design task can be viewed at each individual level of abstraction. The design phases and abstraction levels form the dimensions of Methodical Design method/contents matrix (figure 1).

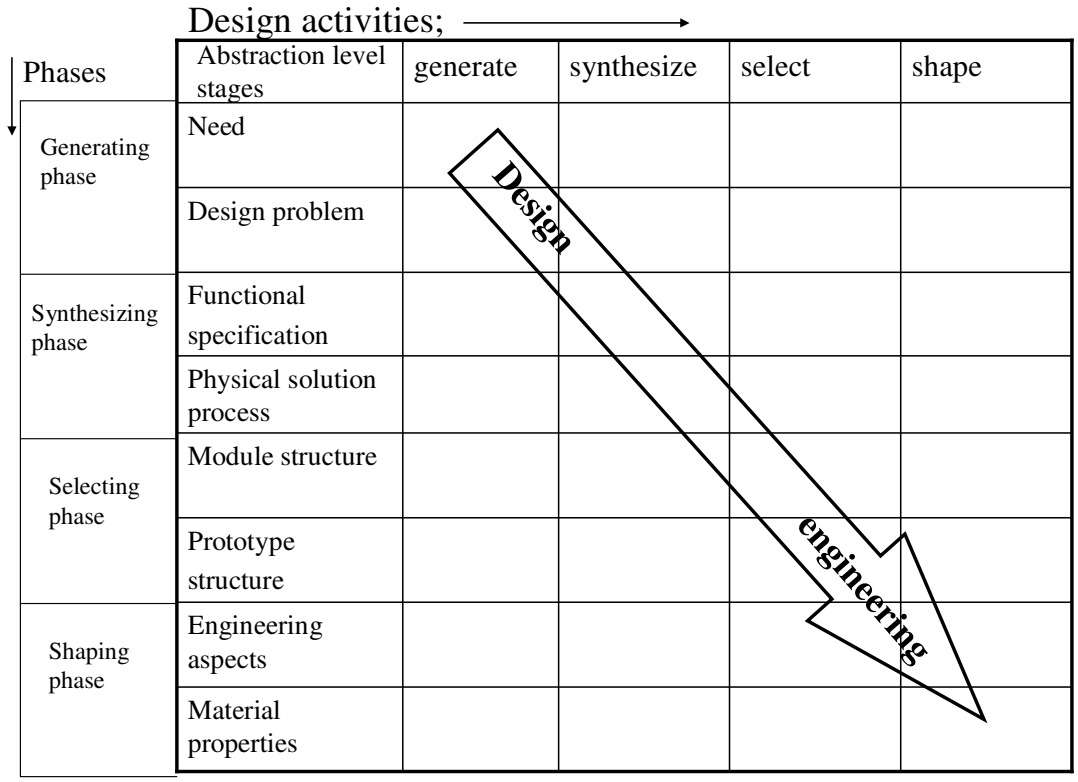


Figure 1. Design method/ contents matrix indicating the phases, abstraction levels

During the design process, and depending on the focus of the designer, functions exist at the different levels of abstraction. Morphology provides a structure to give an overview of the functions considered and the alternative solutions. General Morphological analysis was developed by Fritz Zwicky (Zwicky & Wilson 1967) as a method for investigating the totality of relationships contained in multi-dimensional, usually non-quantifiable problem complexes (Ritchey 2002). Essentially, general morphological analysis is a method for identifying and investigating the total set of possible relationships or “configurations” contained in a given problem complex.
The main aim of this method is to widen the search area for possible new solutions (Cross 1994). The morphological chart gives a complete overview of aspect elements or sub-solutions that can be combined together to form a solution.

The morphological approach has several advantages over less structured methods. We think it may help to discover new configurations, which may not be so evident and could have been overlooked. It has definite advantages for communication and for group work (Ritchey 2002). Morphological overviews represent a design method “intended to force divergent thinking and to safeguard against overlooking novel solutions to a design problem” (Jones 1992). Based on definition of functions, morphological overviews make it possible to assess client’s needs on higher abstraction levels than what a program of requirements (which is often too detailed) provides. Function-oriented strategy, preferred by experienced designers (Fricke 1993), allows various design complexity levels to be separately discussed and, subsequently, (sub)solutions generated to be transparently presented. This facilitates interaction among the participants in the design process, and at the same time structures the information exchange in it (Savanovic 2006).

3. CONNECTING INTEGRAL DESIGN AND REFLECTIVE PRACTICE

Design takes place in an environment that influences the process and so it is contextually situated (Drost & Hendriks 2000, de Vries 1994).The context of a model of design is composed of a “world view”. The de Vries model consists of 3 worlds and is extended by us to include 4 worlds: the real world R, the symbolic world S, the conceptual world C and the specification world M. These worlds are coupled to specific abstraction levels (fig. 2). .

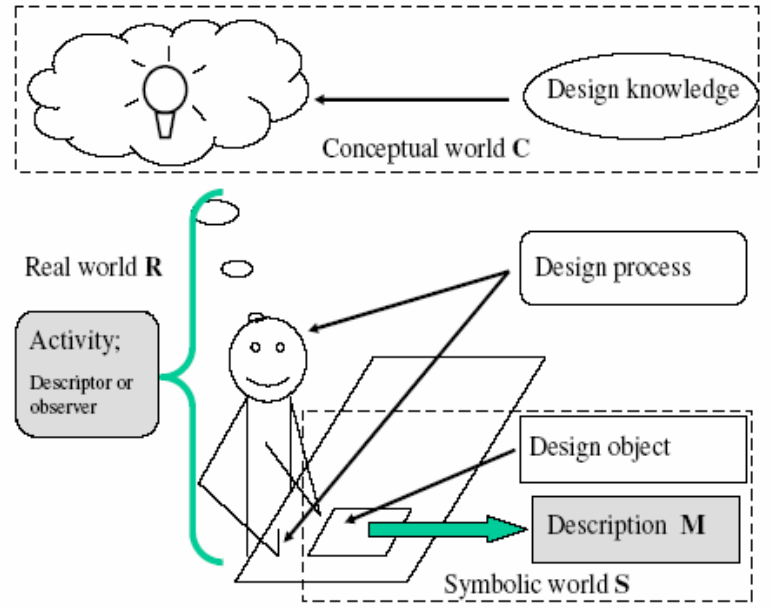


Figure 2: Designer and World view

Distiction is made between the four levels below:

1. Information Level: knowledge-oriented, representing the "conceptual world".
This level deals with the experts' knowledge of the systems. One of the essential ideas behind this is that human intelligence has the capacity to search and to redirect search. This information processing capacity is based on prior design knowledge. One of the major problems in modelling design knowledge is in finding an appropriate set of concepts to refer to the knowledge, or -in more fashionable terms- finding an ontology (Alberts 1993).

2. Process Level: process oriented, representing the "symbolic world".
This level deals with physical variables, parameters and processes. The set of processes collectively determines the functionality of the variables that represent the properties of a device. Modelling at the functional level involves the derivation of an abstract description of a product purely in terms of its functionality. This abstraction reduces the complexity of engineering design to the specification of the product's desired functionality.

3. Component Level: device orientation, representing the "real world".
This level describes the hierarchical decomposition of the model in terms of functional components and is domain dependent. Generic components represent behaviors that are known to be physically realizable. They are generic in the sense that each component stands for a range of alternative realizations. This also implies that the generic components have yet to be given their actual shape.

4. Part Level; parametric orientation, representing "the specification world".
This level describes the actual shape and specific parameters of the parts in the form of which the components exist. Relevant technical or physical limitations manifest themselves in the values of a specific set of parameters belonging to the generic components. These parameters are used to get a rough impression, at the current level of abstraction, of the consequences of certain design choices for the final result.

The relation between the de Vries's model (de Vries 1994) and our conceptual model is shown in fig. 3.

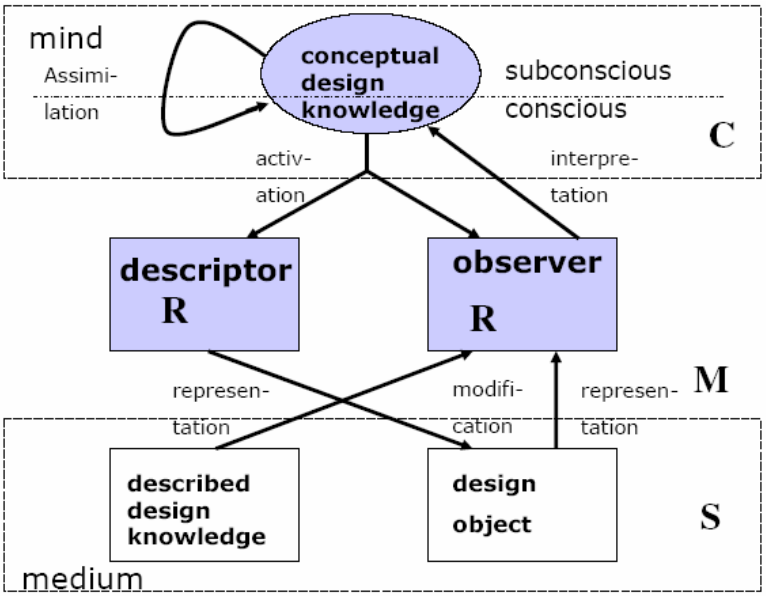


Figure 3: Extended model analytic schematic interaction model of designing

Here a descriptive element in the prescriptive model is introduced by us: the morphological overview. By using the morphological overview as a tool to visualize the representation for use as an element in the interaction between different designers we introduce a reflective element within the Integral Design approach (fig. 4). Integral Design is an example of integration between rational problem solving and Schön's theory of reflective practice (Schön 1983, Roosenburg & Drost 1998).

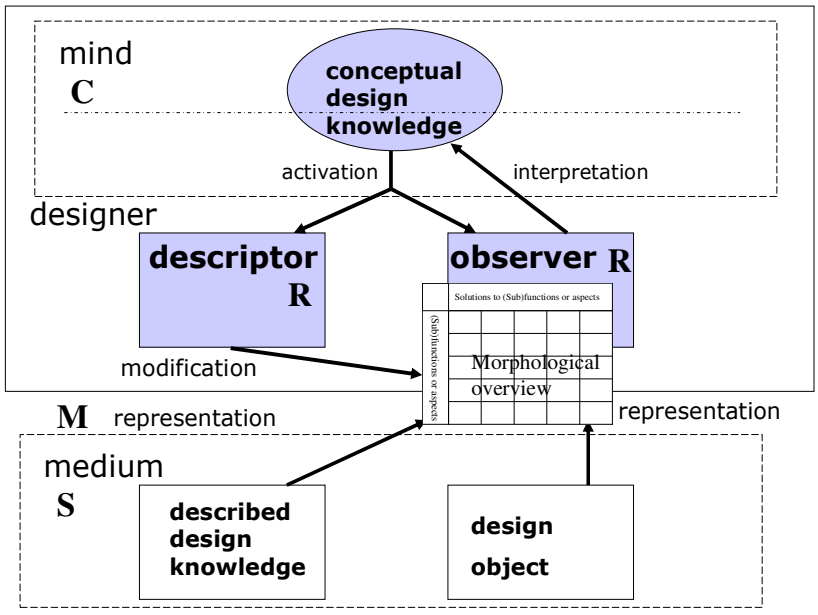


Figure 4: Extended model with the morphological overview as tool for representation and modification

The approach of reflective-practice (Drost 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' (Reyman 2001). Combining aspects of the reflective practice (Schön 1983) in the interpretation phase with the rational problem solving methods in the conceptual design phase will help to overcome a major obstacle: a definition of the'designer objective' criteria as a prerequisite for effective actions during design processes. In reflective workshops the structured problem solving process of methodical design is combined with Schön's reflective practice. In applying Integral Design it is not always important to go through a complete set of design steps within the design process on each level of complexity. Integrating a prescriptive design process matrix with a descriptive / reflective focus on the use of elements within the matrix results in virtual connection between the different approaches (fig. 5).

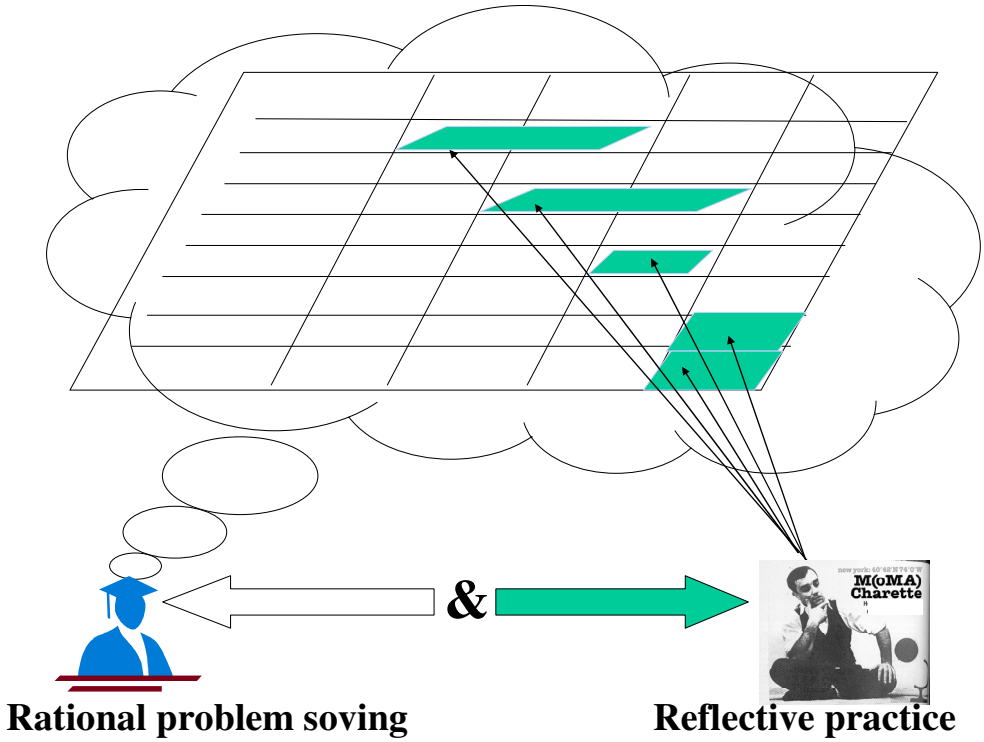


Figure 5: The relation between rational problem solving and reflective practice.

4. EXPERIMENTS

Preliminary tests of the Integral Design methodology with the focus on the Morphological Overviews have been conducted in a series of workshops for experienced professionals from BNA (Society of Dutch Architects) and ONRI (Organization of Dutch Consultants). This was done in order to explore the possibilities to improve on design attitude and capabilities in practice.

Workshops are implemented as a part of the continuous education of professionals from BNA and ONRI (Savanovic et.al. 2006). The workshops are used as experimental settings for research on design teams during the conceptual design phase.
When verifying a new methodological concept, it is not common to work with experienced designers from different disciplines. This is usually done through experiments with student groups (Seegers 2002) or with design groups within one company (Blessing 1994). However, the relevance of the research to everyday design practice is enhanced by involving experienced designers, as there is a major difference in approach between novice and experienced designers (Ahmed et.al 2003, Kavakli & Gero 2003). We believe that a suitable environment for integration activities in building design teams is a workshop setting. A first series of preliminary workshops were organized during the 'Integral Design' project (Quanjel & Zeiler 2003, Zeiler & Quanjel 2007) that was conducted by the Dutch Society for Building Services (TVVL), BNA and Delft University of Technology (TUD). The main conclusions of this project - the suitability of workshops for integration activities among, and the need for structuring the knowledge of, design team members - formed the basis of the development of the new workshops series.

BNA-ONRI-KCBS WORKSHOP

The series of workshops were organized in cooperation with BNA and ONRI. All the participants were experienced practitioners who voluntarily applied to join the "learning-by-doing 'Integral design' workshop course". The only selection criterion we used was the requirement to be a member of either BNA or ONRI. The participants were randomly assigned to design teams, which in the ideal case consisted of one architect, one building physics consultant, one building services consultant and one structural engineer. The design teams in the two BNA-ONRI workshops consisted of professionals who applied via their respective organizations. Ideally, the team line-up was not to change during the workshops. This ideal was not always achievable, a situation that also matches what often happens in every day practice. Therefore the rules were set such that the particular representatives of a discipline as well as their number within one team could change, and only the presence of the discipline itself was treated as crucial. In the first workshop series 24 professionals participated: 5 architects, 6 structural engineers, 5 building physics consultants and 8 building services consultants. In the second workshop series 19 professionals participated: 6 architects, 1 structural engineer, 5 building physics consultants, 6 building services consultants and one manager. In total there were 43 participants organized in 9 design teams.

The workshops consist of three half-day sessions that take place once a week, meaning that there is a gap of seven days between every two sessions. This configuration is the result of the experiences gained in previous tryouts (Quanjel & Zeiler 2003). In the year 2005 two workshop series were organised. The first workshop took place on 31 May, 7 and 14 June, and the second workshop on 24, 31 October and 7 November. The same assignment, to design a small 'pavilion for sustainable architecture' on the building in which the workshops were located, was given to all the design teams in all the two workshop series. Four different subjects were covered;

Day 1	Day 2	Day 3
interpretation	generation	selection and integration

Table 1. Workshop series main subjects

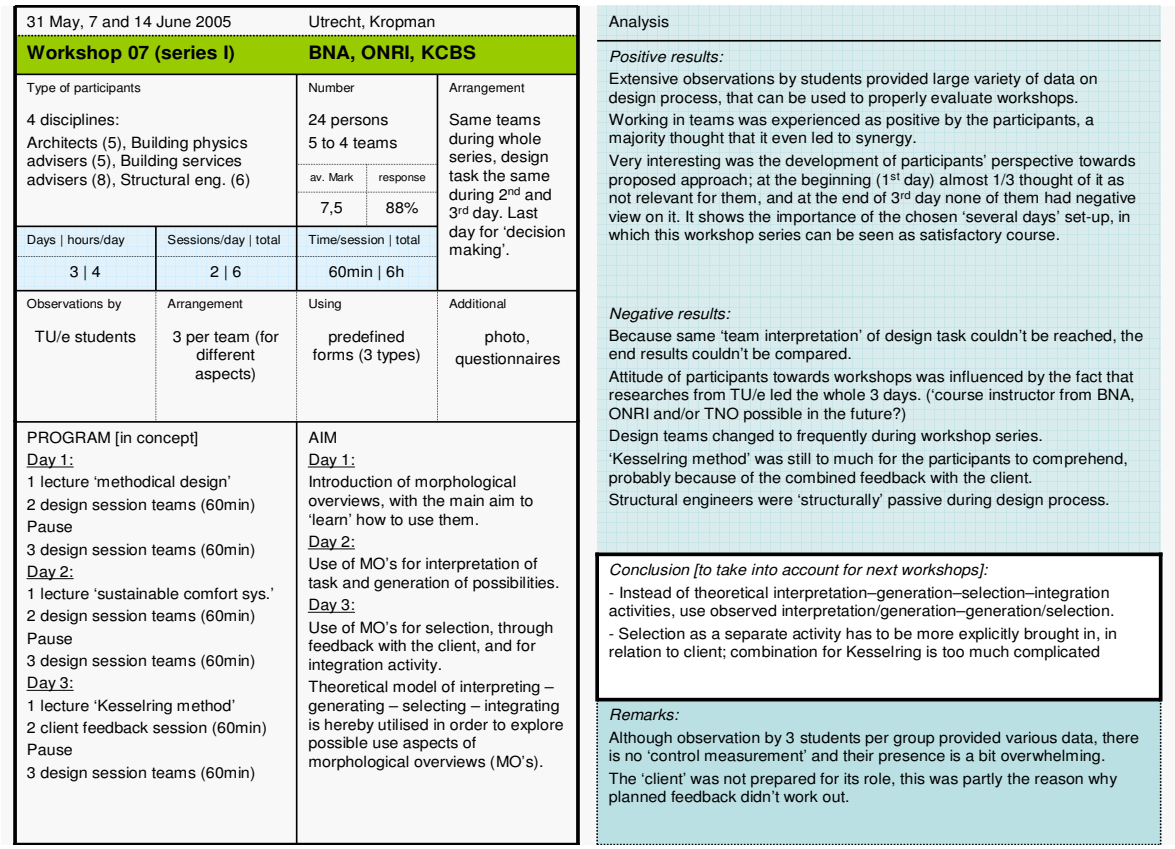
The first workshop session can be seen as for team building session and at the same time for training in aspects of methodical design. The design team formation was random, meaning that none of the participants worked together before, which is often also the case in their regular practice. To avoid the common practice of spending much of the time in the first meeting just to get better acquainted with each other, the teams were asked to directly proceed with work on the design task. Morphological overviews were presented as a way to structure this accelerated design process. The teams were not forced to use the morphological overviews. However, they were instructed on how to do it, after which a design assignment had to be completed for a short presentation. At the end of the first half-day session the teams had to give short presentations to each other about their conceptual ideas. After the assignment presentation the design process was only observed and no further intervention took place.

On the second day the same design teams were given a larger design assignment. The task was to design a zero-energy multifunctional office building on a standard location. The focus was on generating possibilities as anticipated in different disciplines, using the morphological overviews. Unlike the first day, at the end of the second day, the teams did not have to present the provisional results. Instead, the whole design session was used for the generation of possibilities. During the last day the design teams had to integrate the proposed sub solutions into an integral office building design. The team's generation and integration of possibilities were to be achieved through communication, but this aspect of the use of morphological overviews was consciously experienced only during the communication with someone outside the design team itself. At the end of the session the design teams had to present their final integral design proposals to the other design teams.

Observations and evaluations

Measurements were conducted in four different ways:
(1) through direct observations of the design teams' activities (from within teams themselves, using observation forms),
(2) by taking photographs of the design team during their work (at 10min intervals),
(3) through analysis of the material produced by the design teams, and
(4) by asking theparticipants to fill in a number of questionnaires (one after each ½-day session).

The general communication patterns and use of morphological overviews during the design process were evaluated. Two types of communication patterns were looked at: from one discipline to another and team-oriented communication. Morphological overviews could be used either for communication or for the introduction of design solutions. Putting it simply, the focus was separately on 'designing' and 'communicating', with 'designing' reduced to the explicit production of solutions. The overviews and the set-up of the workshops are given in figure 6, 7 and 8.



31 May, 7 and 14 June 2005		Utrecht, Kropman	
Workshop 07 (series I)		**BNA, ONRI, KCBS**	
Type of participants 4 disciplines: Architects (5), Building physics advisers (5), Building services advisers (8), Structural eng. (6)		Number 24 persons 5 to 4 teams av. Mark: 7,5 / response: 88%	Arrangement Same teams during whole series, design task the same during 2nd and 3rd day. Last day for 'decision making'.
Days | hours/day 3 | 4	Sessions/day | total 2 | 6	Time/session | total 60min | 6h	
Observations by TU/e students	Arrangement 3 per team (for different aspects)	Using predefined forms (3 types)	Additional photo, questionnaires
PROGRAM [in concept] Day 1: 1 lecture 'methodical design' 2 design session teams (60min) Pause 3 design session teams (60min) Day 2: 1 lecture 'sustainable comfort sys.' 2 design session teams (60min) Pause 3 design session teams (60min) Day 3: 1 lecture 'Kesselring method' 2 client feedback session (60min) Pause 3 design session teams (60min)		AIM Day 1: Introduction of morphological overviews, with the main aim to 'learn' how to use them. Day 2: Use of MO's for interpretation of task and generation of possibilities. Day 3: Use of MO's for selection, through feedback with the client, and for integration activity. Theoretical model of interpreting – generating – selecting – integrating is hereby utilised in order to explore possible use aspects of morphological overviews (MO's).	

Analysis

Positive results:
Extensive observations by students provided large variety of data on design process, that can be used to properly evaluate workshops.
Working in teams was experienced as positive by the participants, a majority thought that it even led to synergy.
Very interesting was the development of participants' perspective towards proposed approach; at the beginning (1st day) almost 1/3 thought of it as not relevant for them, and at the end of 3rd day none of them had negative view on it. It shows the importance of the chosen 'several days' set-up, in which this workshop series can be seen as satisfactory course.

Negative results:
Because same 'team interpretation' of design task couldn't be reached, the end results couldn't be compared.
Attitude of participants towards workshops was influenced by the fact that researches from TU/e led the whole 3 days. ('course instructor from BNA, ONRI and/or TNO possible in the future?)
Design teams changed to frequently during workshop series.
'Kesselring method' was still to much for the participants to comprehend, probably because of the combined feedback with the client.
Structural engineers were 'structurally' passive during design process.

Conclusion [to take into account for next workshops]:
- Instead of theoretical interpretation–generation–selection–integration activities, use observed interpretation/generation–generation/selection.
- Selection as a separate activity has to be more explicitly brought in, in relation to client; combination for Kesselring is too much complicated

Remarks:
Although observation by 3 students per group provided various data, there is no 'control measurement' and their presence is a bit overwhelming.
The 'client' was not prepared for its role, this was partly the reason why planned feedback didn't work out.

Figure 6: Overview workshops professionals BNA and ONRI 31 May, 7 and 14 June 2005

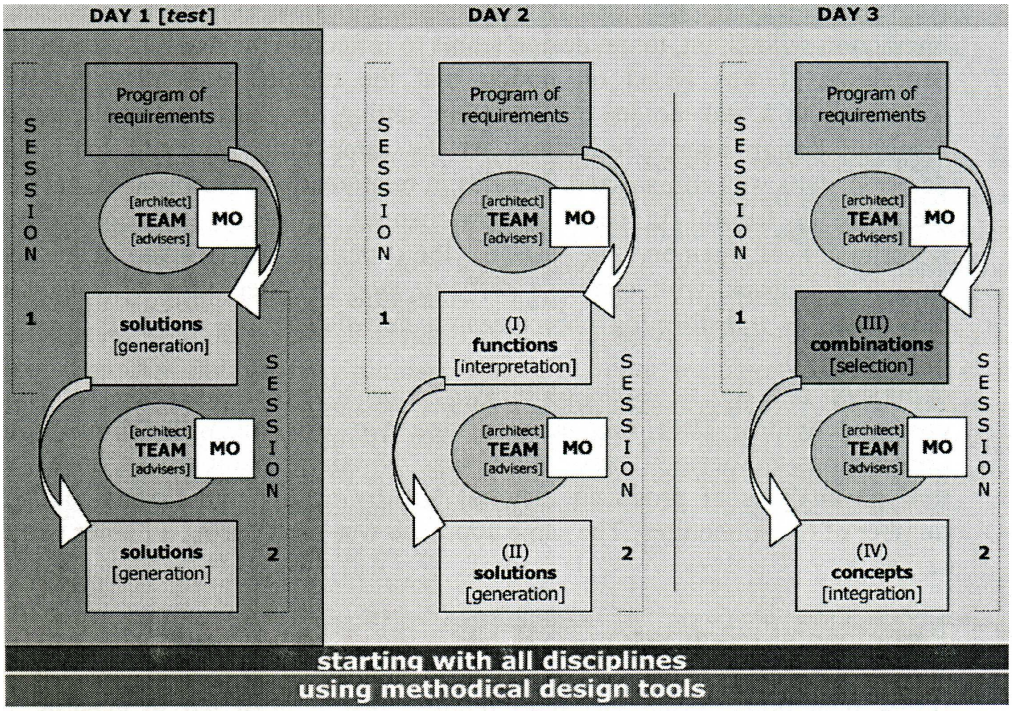


Figure 7 : set-up of the workshops

24, 31 October and 7 November 2005		Delft, TNO Bouw	
Workshop 09 (series II)		**BNA, ONRI, KCBS**	
Type of participants 5 disciplines: Architects (6), Building physics advisers (5), Building services advisers (6), Structural eng. (1), Manager (1)		Number 19 persons 5 teams av. mark: 7,0 / response: 96%	Arrangement Same teams during whole series, design task the same during 2nd and 3rd day. Last day for 'client' feedback.
Days | hours/day 3 | 4	Sessions/day | total 2 | 6	Time/session | total 60min | 6h	
Observations by ADMS students	Arrangement 2 per team	Using predefined form	Additional photo, questionnaires
PROGRAM [in concept] Day 1: 1 lecture 'methodical design' 2 design session teams (60min) Pause 3 design session teams (60min) Day 2: 1 lecture 'sustainable comfort sys.' 2 design session teams (60min) Pause 3 design session teams (60min) Day 3: 1 lecture 'relation with the client' 2 client feedback session (60min) Pause 3 design session teams (60min)		AIM Day 1: Teams were not obliged to work with morphological overviews, main aim was to learn how to use them. Day 2: Results from day 1 used to point out what the advantage is of integral approach. Emphasise also on use of MO's for feedback with the client. Day 3: 'Learning effect' was mainly expected to emerge from interaction with client; transparency of process and design decisions should show the added value.	

Analysis

Positive results:

Although only one manager was involved in workshop, it showed that their contribution within design team setting in conceptual design phase is not relevant (with respect to design content).

Morphological overviews were differently used within different-sized design teams. They were considered helpful in structuring the communication of design teams, especially in more complicated situations. Four-discipline teams used them more for communication purposes than 3-discipline teams. This statement is backed up by the results of the various questionnaires that all participants were given, regardless of discipline or the design team arrangement.

Negative results:

Use of ADMS students didn't produce better observations than last time, when TU/e students observed.

Big differences in experience between participants caused sometimes too big unbalance within design teams; as addition to the absence of structural engineers.

Feedback with client was a step too far, just as previous attempts to introduce 'Kesselring-method' for decision making processes. It seems that 'only' the use of 'morphological overviews', as a basic tool for structuring design process, is more than enough in this short amount of time.

Conclusion [to take into account for next workshops]:

- Introduce only use of morphological overviews, in relation with thinking in abstraction levels.
- Clients need to be 'real' in order to get more commitment from participants.

Remarks:

BNA / ONRI representatives acted as clients.

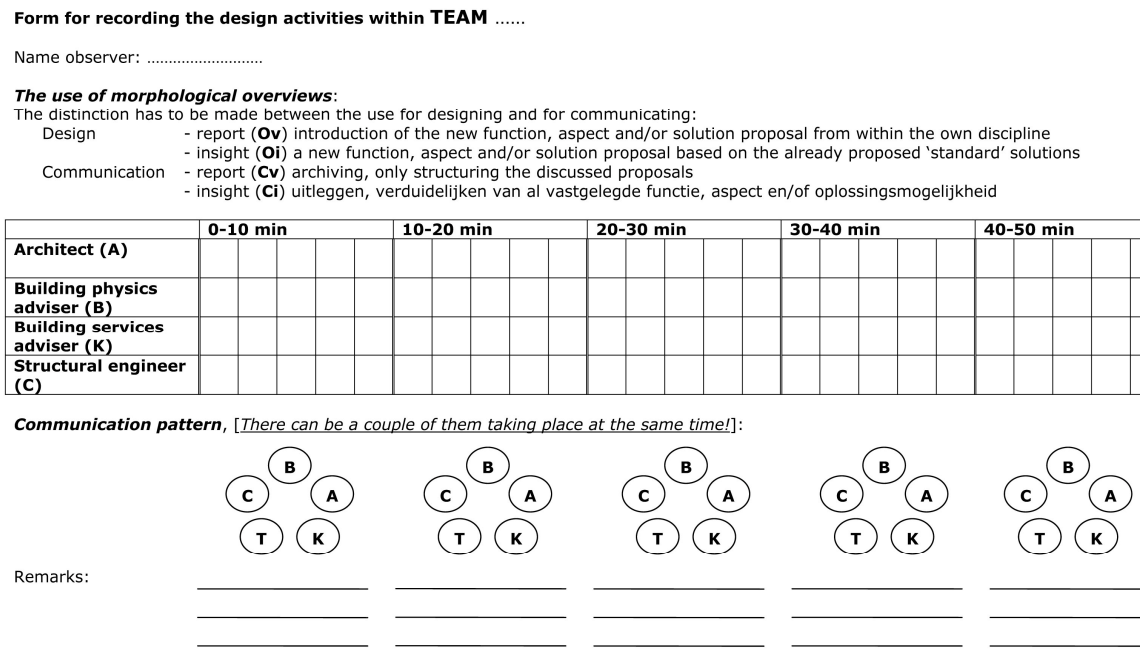
Workshops were led by TNO representative, this is preferred setting for conduct research because of unobtrusive presence of researches.

Some participants still complained about 'many' student-observers.

Figure 8: Overview workshops professionals BNA and ONRI 24, 31 October and 7 November 2005

5 RESULTS

The observations were made by students using the observation form shown in fig. 9.



Form for recording the design activities within TEAM .....

Name observer: .....

The use of morphological overviews:
The distinction has to be made between the use for designing and for communicating:

Design
- report (**Ov**) introduction of the new function, aspect and/or solution proposal from within the own discipline
- insight (**Oi**) a new function, aspect and/or solution proposal based on the already proposed 'standard' solutions

Communication
- report (**Cv**) archiving, only structuring the discussed proposals
- insight (**Ci**) uitleggen, verduidelijken van al vastgelegde functie, aspect en/of oplossingsmogelijkheid

	0-10 min	10-20 min	20-30 min	30-40 min	40-50 min
Architect (A)					
Building physics adviser (B)					
Building services adviser (K)					
Structural engineer (C)					

Communication pattern, [*There can be a couple of them taking place at the same time!*]:

Remarks: _____ _____ _____ _____ _____

Figure 9: Observation form

The observation results of the two workshop series are shown in table 2. The general communication patterns and the use of the proposed morphological overviews during the design process were measured. The communication could take place from one discipline to another, or it could be team-oriented. The morphological overviews could be used either for introducing design solutions or for communication. During the observations of the two workshop for design and for communication, a distinction between reporting and giving/acquiring insight was made.
In the first series all the teams consisted of members from four disciplines, while in the second series most of the teams consisted of members from three disciplines.

The evaluation of the two workshop series showed that the team configuration does influence the aspects measured [Savanović et al 2005]. The 3-discipline design teams developed some kind of mutual understanding and agreement faster than the 4-discipline design teams. This was not directly related to the use of morphological overviews for communication purposes. In comparison, the 4-discipline design teams, which internally communicated more on a 1-on-1 basis, used morphological overviews more frequently for communication purposes.

4- and 3-discipline teams comparison professionals' workshops			Day 1		Day 2		Day 3		average	
			4-d	3-d	4-d	3-d	4-d	3-d	4-d	3-d
Communication	1 on 1	arch ↔ adv	35%	67%	44%	29%	33%	31%	37%	42%
		adv ↔ adv	42%	11%	34%	12%	34%	16%	37%	13%
	Team		23%	22%	23%	58%	33%	53%	26%	44%
Morphological overviews	Design	Report	22%	41%	68%	71%	31%	53%	40%	55%
		Insight	0%	25%	1%	11%	6%	13%	2%	16%
	Comm.	Report	13%	13%	3%	4%	15%	15%	10%	11%
		Insight	64%	21%	28%	14%	48%	18%	47%	18%

Table 2. Observation results from the two workshop series with professionals from BNA and ONRI

The design process was photographically captured at 10 minute intervals. This way the development in time of the number of proposed alternatives was registered. Through quantitative changes in the number of proposed alternatives the generation activities of the design teams could be traced. The second day was the most important for measuring the use of morphological overviews for the purpose of generating solution proposals. The first day was, because of the non-obligatory approach, considered a training session, and the focus on the third day was on the integration of the proposals generated. It must to be stressed that the quality of the alternatives/proposals generated has not been determined. The purpose was to research on whether if the use of the morphological overviews leads to the widening of the field of possibilities, which seems to be the case.

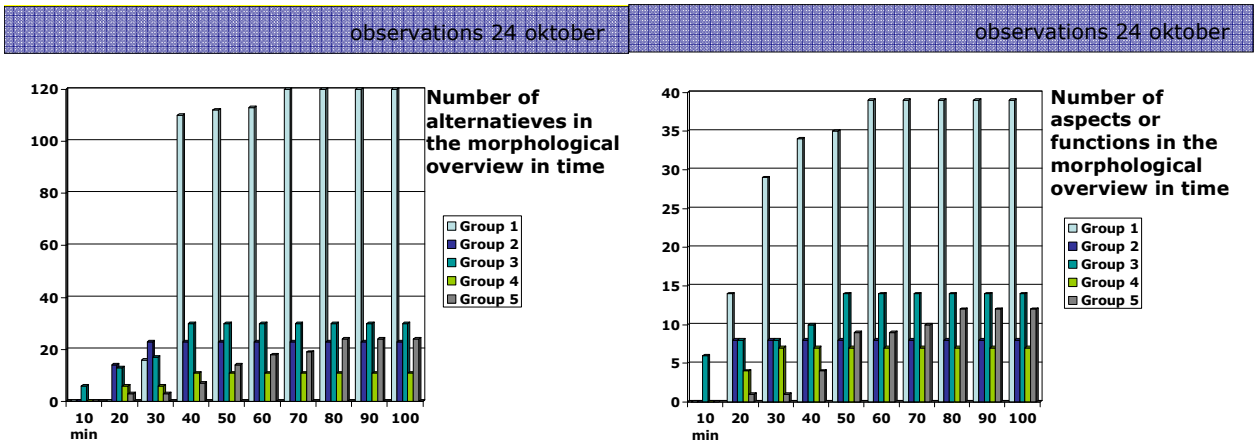


Figure 10. Number of produced functions/aspects and alternatives by professional design teams

Conducting questionnaire surveys helped in further evaluation of the use of morphological overviews. The importance of the proposed approach for the everyday practice was confirmed by 61% of the participants, with29% being uncertain, and 10% seeing it as unimportant. These results were based on the responses from 33 out of the 34 participating designers. Only 6% of the practitioners considered the use of morphological overviews irrelevant for their discipline, and 13% thought that it was not positive for communication within a design team setting. However, the majority was convinced that morphological overviews were beneficial in terms of the following: the number of relevant alternatives produced (66% yes-answers). We also asked the participants to rate the relevance of Morphological Overviews for specific aspects on a scale from 1 to 10: number of alternatives generated, team design process, raising the awareness of contributions from other disciplines,)and, of course, communication (7.2) (tabel 3).

Morphological overviews are relevant for:	
number of alternatives	6.8
team design process	7.2
contribution of 'others'	7.4
communication	7.2

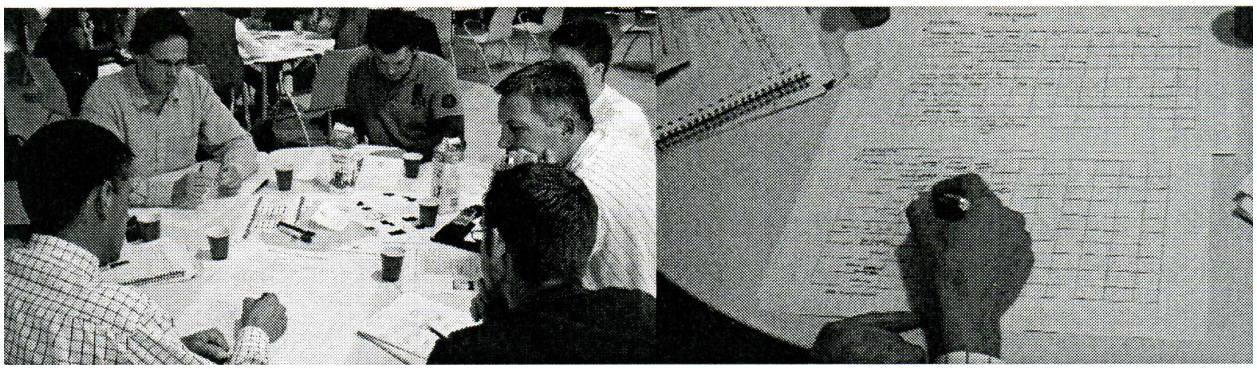
Tabel 3: Ratings of professionals (on 1-10 scale) regarding the use of morphological overviews

The expected use of morphological overviews in everyday practice was low with only 36% answering this question 'highly likely'. The effect of morphological overviews on the final design proposals was, on average, found to not be positive, with only 43% of participants thinking of it as beneficial (tabel 4).

Aspect of reaction asked	
Find proposed approach important	61%
Expect to use morphological overviews	36%
Overviews beneficial for final proposals	43%

Tabel 4: Percentage of positive reactions by professional participants workshops

This last aspect seems to contradict the ratings of mutual team presentations, concerning the professional design teams. Without judging their quality, the proposed solutions were rated (by the participants themselves) for their innovativeness. The participants could not rate the presentation of their own team. The best rated design proposals, which were at the same time seen as the most integral solutions, could indeed be linked with high use of morphological overviews.



5. CONCLUSION

"*It is impossible to teach somebody something; one can only assist him in finding it within himself.*"
Galilei Galileo (1564-1643)

It is necessary during design team cooperation to overcome difficulties caused by lack of information and lack of knowledge. By structuring the interactions of the consultants in the conceptual phase of design it is possible to resolve much of the influence/information contradiction at the early stages of the design process. The aim is to help members of every discipline to handle tasks and make decisions with the support of information from other disciplines. Implicit explanation supplied by structuring this information will improve understanding of the combined efforts. It is assumed that designers survey a problem, form a judgment about critical areas in the design matrix and make decisions about how the focus of attention may be optimized. Introducing the descriptive morphologic overview as an element of reflective practice results in the Integral Design method. Morphological overview is a tool to structure the information from and communication between the different design disciplines involved in the conceptual phase of the design process. The Integral Design methodology makes it possible to work in a structured and transparent way using the framework of the Integral Design matrix. It is for the designers to make decisions about which elements of the matrix he wants to use. Integral Design should not be considered as a recipe for all processes, but it is a good recipe to learn cooking with. Gradually designers will modify the method they use and improve it. Integral Design should be a set of rules which designers can start with, as well as improve upon. By fostering the practice of research within itself through participation in the "Learning by doing" workshops and by constantly reflecting upon these activities to improve them, design becomes a "reflective consistent" discipline.

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References

Ahmed S., Wallace K.M., Blessing L.T.M., 2003, Understanding the differences between how novice and experienced designers approach design tasks, Design in Engineering Design 14 (2003), Springer-Verlag.

Aken J.E. van, 2003, On the design of design processes in architecture and engineering: technological rules and the principle of minimal specification, In working paper 03.08, Eindhoven Centre for Innovation Studies, June 2003, Technische Universiteit Eindhoven.

Alberts L.K., 1993, YMIR: An Ontology for Engineering Design, PhD-thesis, University of Twente, Enschede.

Blessing L.T.M., 1994, A process-based approach to computer supported engineering design. PhD thesis Universiteit Twente.

Boer S.J. de, 1989, Decision Methods and Techniques in Methodical Engineering Design, PhD-thesis, University Twente, ISBN 90-72015-3210

Bucciarelli L.L., 1994, Designing Engineers, MIT Press, Cambridge, Mass.

Cross N. Roozenburg N., 1992, Modelling the Design Process in Engineering and in Architecture. In: Journal of Engineering Design, no. 4/1992, pp. 325-337.

Cross N., 1989, Engineering Design Methods, Wiley, Chichester

Cross N., 1994, Engineering design methods: strategies for product design, 2nd.ed., John Wiley & Sons, New York

Dorst K. ,1997, Describing design: a comparison of paradigms, PhD-thesis, Technische Universiteit Delft, Delft.

Drost K., Hendriks D., 2000, The Role of the Design Context: In Practice and in the design Methodology, Proceedings 5th International Design thinking research Symposium "Designing in Contect"' DTRS2000, 18-20 December, Delft

Fricke G.., 1993, Kostruieren als flexiber Problemlöseprozes – Empirische Untersuchung über erfolgreiche Strategien und methodische Vorgehensweisen. Düsseldorf, VDI-Verlag.

Jones J. C., 1992, Design methods, New York, Van Nostrand Reinhold.

Kavakli M., Gero J.S., 2003, Difference between expert and novice designers: an experimental study, in U. Lindeman et al (eds), Human Behaviour in Design

Kroonenberg H.H. van den, Siers, F.J. 1992, Methodisch ontwerpen, Educaboek BV, Culemborg (dutch).

Quanjel, E.M.C.J., Zeiler, W., 2003, 'Eindrapportage Onderzoek Integraal Ontwerpen' , TUD, The Netherlands. (dutch)

Reyman I.M.M.J., 2001, Improving Design Processes through Structured Reflection: Case Studies, in SAI Report 2001/3, Eindhoven, ISSN 1570-0143

Ritchey T., 2002, General Morphological Analysis, A general method for non-quantified modeling, 16th EURO Conference on Operational Analysis, Brussels 1998.

Roozenburg, N.F.M., Dorst, C.H. ,1998, Describing Design as Reflective Practice in Frankenberger, E., Badke-Schaub, P., Birkhofer, H. (eds) Designers - The Key to Successful Product Developent, Berlin: Springer.

Roozenburg, N.F.M., Eekels, J., 1995, Product Design, Fundamentals and Methods, John Wiley & Sons, Chichester, UK

Savanović P, Zeiler W, Trum H.M.G.J., Borsboom W.A.. Integral building design methodology in the context of sustainable comfort systems', CIB W096 Architectural Management, Technical university of Eindhoven, July 2006.

Savanovic P., 2006, Dynamic briefing for adaptable building design. In Adaptables 2006; Joint CIB, Tensinet, IASS International Conference on Adaptibility in Design and Construction. Eindhoven, The Netherlands.

Schön D.A., 1983, The reflective practitioner: how professionals think in action, London, Temle Smith, ISBN 1-85628-262-7

Segers N.M., 2002, Towards a data-structure that can handle ambiguous information in a computer-aided tool for early phase of architectural design, Proceedings of the 6th International Conference Design & Decision Support Systems in Architecture, July 7-10 2002, Ellecom

VDI, 1987, Systematic approach to the design technical systems and products, VDI-Guidline 2221, VDI-verlag

Vermaas P.E., Dorst K., On the conceptual framework of John Gero's FBS-model and the prescriptive aims of design methodology, 2007, Design studies, doi:10.1016/j.destud.2006.11.001

Vries T.J.A. de, 1994, Conceptual design of controlled electro-mechanical systems, a modeling perspective, PhD thesis Twente university, Enschede, ISBN:90-9006876-7

Zeiler W., 2000, Integral Design and Building performance Simulation, International Building performance Simulation Association (IBPSA) symposium Building performance simulation in the Benelux, Eindhoven, 27 october 2000.

Zeiler W., Quanjel E.M.C.J., 2007, Using methodical design for starting a culture change in Dutch building design practice; collaboration TVVL, BNA and TU Delft 2000 - 2003 CONNECTED 2007 International Conference on Design Education, 9 – 12 July 2007, University of New South Wales, Sydney, Australia

Zwicky F., Wilson A.G. (eds.), 1967, New Methods of Thought and Procedure. Contributions to the Symposium on Methodologies, May 22-24, Pasadena, New York Springer Verlag