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INTEGRAL BUILDING DESIGN WORKSHOPS; COMPARING STUDENTS AND PROFESSIONALS

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1. Introduction

Since 2001 we have been propagating 'integral approach' within Dutch building design practice, through continuously developing learning-by-doing workshops. Integral approach represents a broad view on the world around us that continuously needs to be adapted and developed from sound and documented experiences that emerge out of interaction between practice, research and education. This integral approach can eventually lead to integral process, team and method – all the required conditions for design of the end product. Implicit to this broad view is that integral design solutions are only possible through unification of different viewpoints on the same aspects. This is the reason we assume that a multi-discipline design team view on design is an effective way to pursue building design integration. The aim is to improve conceptual design (process level) by defining an 'integral design (ID) methodology' that would increase potential for creation of integral building designs (product level). Positive results on these two levels are assumed to eventually trigger and support culture change within (Dutch) building design practice.

2. Integral Design methodology

To be able to deal with problems as complex as design problems an important strategy is decomposition: breaking down the overall problem into its sub-problems and synthesizing a complete solution by combining partial solutions. Decomposition divides design work and so it enables teamwork (Blessing 1994, p.39). As stated by Blessing (1994, p.41): "The model proposed by van den Kroonenberg (1978) can provide a starting point for the inclusion of the decomposition strategy". 'Methodical design' model is used as a framework for structured introduction of discipline-based object design knowledge. This model is problem oriented and distinguishes, based on functional hierarchy, various abstractions and/or complexity levels during different design stages and design phase activities. Its important feature is the use of morphological overviews (both for the overall description of design stages as for separate design activities). 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 program of requirements (which is often too detailed) provides.

It is important to stress that the major step in understanding how to work with morphological overviews is to separate concept *integration* from plain *combination* of (sub) solutions. Concept integration involves *transformation* of object design knowledge, for which 'ID-methodology' is meant as catalyst. The connections design team members make between (sub) solutions / design aspects in order to produce integral concepts are subjective and dependent on both design task and context.

Therefore, the essence of 'ID-methodology' is strict separation between synthesizing design proposals and selecting the suitable ones.

2.1 Workshop formula

We believe that a suitable environment for integration of activities of building design teams is a workshop setting. The first series of workshops were organized during 'Integral Design' project [Quanjel and Zeiler, 2003] 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 of design team activities and a need for structuring knowledge of design team members, formed the basis for further development of workshops within PhD-projects initiated by Knowledge Centre Building and Systems (TNO-TU/e).

3. Experiments

3.1 BNA-ONRI-KCBS workshops

The still ongoing series of workshops are organized in cooperation with BNA and ONRI. All participants are experienced practitioners who voluntarily apply for "learning-by-doing 'Integral design' workshop course". The only selection criterion we use is the requirement to be a member of either BNA or ONRI. The participants are randomly assigned to design teams, which ideally would consist out of one architect, one building physics consultant, one building services consultant and one structural engineer. However, since the organization of workshops is dependent on spare time of experienced practitioners, it often happens that not all disciplines are represented within a design team. This circumstance led to interesting observations. During two workshop series (each consisted of 3x 4-hour sessions) that were held in 2005, two types of design teams could be discerned: 4-discipline and 3-discipline teams, see figure 1 for the set up of the workshops.

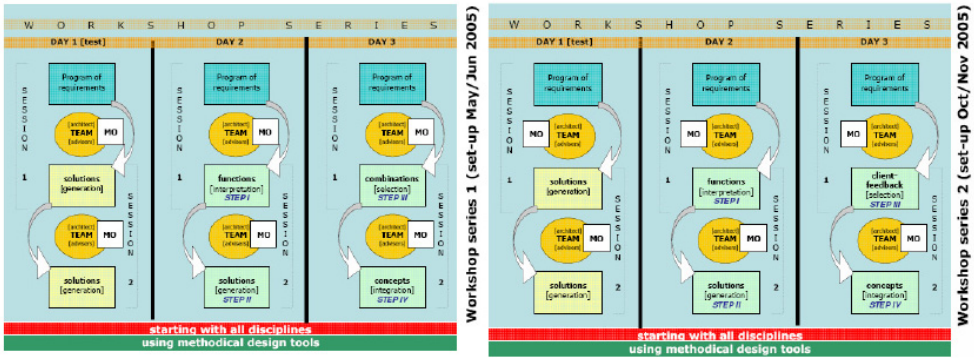


Figure 1. Set up of the workshops series 1 & 2 2005

On the first day the main focus was on the team interpretation of the design tasks. The formation of design teams were random, meaning that none of the participants worked together before, which is often also the case during the daily practice. The crucial aspect for learning in a team is the creation of the shared understanding. This is mostly a slow process that is often based on the social aspects of the interaction between the team members. To avoid these common practice situations where the purpose of the meetings is just to get better acquainted with each other, the teams were asked to directly proceed with the interpretation of the presented design task. The morphological overviews were used to structure this accelerated design process. The background information concerning methodical design and morphological overviews was beforehand sent to all participants. In addition, the lecture about the subject proceeded the actual design sessions. Because the basic principle of the workshop set-up was to avoid the 'laboratory situation', the teams were not forced to use the overviews. However, they were instructed how to use them, after which the presented design assignment had to be

worked out in 90 minutes for a short presentation. The assignment was to design a small 'pavilion for sustainable architecture' on the building the workshops were taking place in. After the assignment presentation the design process was only observed and no further intervention took place. At the end of the day the teams had to give short presentations to each other about their conceptual ideas. The first day can be seen as a team building session, but at the same time also as a kind of training for the use of methodical design aspects.

Table 1. Design tasks

Day 1	**Day 2**	**Day 3**
A small pavilion	Zero-energy multifunctional office	

The second day the same design teams were given larger design assignment. The task was to design a zero-energy multifunctional office building on a standard location. This time the focus was on the generation of the possibilities from different viewpoints, as anticipated by different disciplines. Before the generation of possibilities the design teams again had to first come to the mutual interpretation of the assignment. The expectation was that with the experience of the first day the design teams would need less time to effectively do this. For both interpretation and generation the morphological overviews were used. The TNO contributed to the search of the zero-energy solutions by giving an overview lecture on sustainable comfort systems before the start of actual design sessions. In contrast to the first day, at the end of the second day the teams did not have to present the provisional results. Instead they could use the whole 120-minutes design session 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. But before making the final choice they had to report to the client what the status of the design was, which choices were made and why, and which were yet to be made based on which assumptions and/or design team proposals. In order to explain the transparency of the design process to the client the same morphological overviews were to be used. This way the use of the overviews for the external communication was also observed. The use of the same tool, in this case the morphological overviews, for both internal as external communication can show the applicability of the use of overviews in structuring and solving the various aspects of the design task.

Table 2. Workshop series main subjects

Day 1	**Day 2**	**Day 3**
Task interpretation	Generation of possible solutions	Selection and solution integration

The team's interpretation and generation are achieved through communication, but this aspect of the use of morphological overviews is only explicitly shown during the communication with someone that stands outside the design team itself.
One other aspect, the potential for archiving the solution steps, is emphasised at the same time. This is particularly helpful in relations with various external parties, new team members or for refreshment of memory in the case of long periods of project delays. The client role was 'played' by a representative from either the ONRI or the BNA organisation. After the feedback from the 'client' the design team had to propose the final integral design solution and present it to the other design teams. During short presentations, both on the first and on the final day, the participants rated each other. They did not, however, rated the results of their own design team. To summarise, each day was dedicated to a certain subject and on the 2nd and 3rd day the participants got the feedback from previous days. The main topics were: 'Methodical design' on the first day, 'Sustainable comfort systems' on the second and the importance of 'The role of the client for the quality of design' on the third and final day.
The total number of observed design teams was 9. Because 4-hour sessions were spread over three weeks, the teams' arrangements changed during that period. Only two out of nine teams had the entire time 4-discipline configuration, four teams were switching between 4-discipline to 3-discipline configurations, while three teams retained 3-discipline configuration during the whole workshop series. It was observed that (development of) design team communication was influenced by the

number of design disciplines within a design team. The 3-discipline design teams developed some kind of mutual understanding and agreement faster than 4-discipline design teams. This was not directly related to the use of morphological overviews. On contrary, 4-discipline design teams, which internally communicated more on a 1-on-1 basis, used morphological overviews more frequently for communication purposes. Generally, from the observation results could still be concluded that morphological overviews were helpful in aiding communication / structuring object design knowledge of the design teams, especially in more complex situations (when more disciplines were involved).

3.2 Multidisciplinary masters' project

Because interaction between practice, research and education forms the core of 'integral approach', the same workshop and methodology are applied within multidisciplinary masters' project on TU/e, Department of Architecture, Building and Planning. The first edition of this project, initiated by the Building Services chair of Building Physics and Systems unit, took place in 2005/06 academic year.

3.2.1 Project setting

The students from architecture, building physics, building services, building technology and structural engineering were offered the opportunity to participate. The procedure was the same as for BNA-ONRI-KCBS workshops; the only criterion for participation was the 'membership' of 'master students group'. The students were per discipline randomly assigned to design teams, with the aim to have all disciplines represented in each team. However, partly because of the differences in time schedules of their curricula, building physics and structural engineering students did not participate. This effectively resulted in the same type of situation as happened with practitioner teams, namely formation of 3-discipline instead of the preferred 4-discipline design team arrangement. In total 25 students participated: 9 from architecture, 6 from building technology and 10 from building services. They were assigned to 6 different design teams. None of the teams had an ideal formation (of one representative per discipline). The 'redundant' architecture and/or building services students were asked to abstain from any design team activities, and instead act as observers. Besides producing research data, by observing they were able provide valuable feedback to their own teams after the workshops. The whole project lasted 10 weeks. The specific aspect of the office building design assignment was to realise 'sustainable comfort', a Zero Energy Solution, bearing in mind the current situation where 40% of primary energy consumption is due to built environment. Such a complex task requires early collaboration of all design disciplines involved in the conceptual building design. Development of knowledge and skills to be able to realise this aim is the main task of the multidisciplinary masters' project 'Integral design'. During the first three weeks BNA-ONRI-KCBS workshop formula was used for the improvement of design team work. At that stage of development, the workshop consisted of three ½-day sessions that took place once a week; with a gap of seven days in-between each session. All disciplines within design teams are considered equal; synergy out of specific individual contributions is the aim.

4. Measurements, observations and evaluations

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

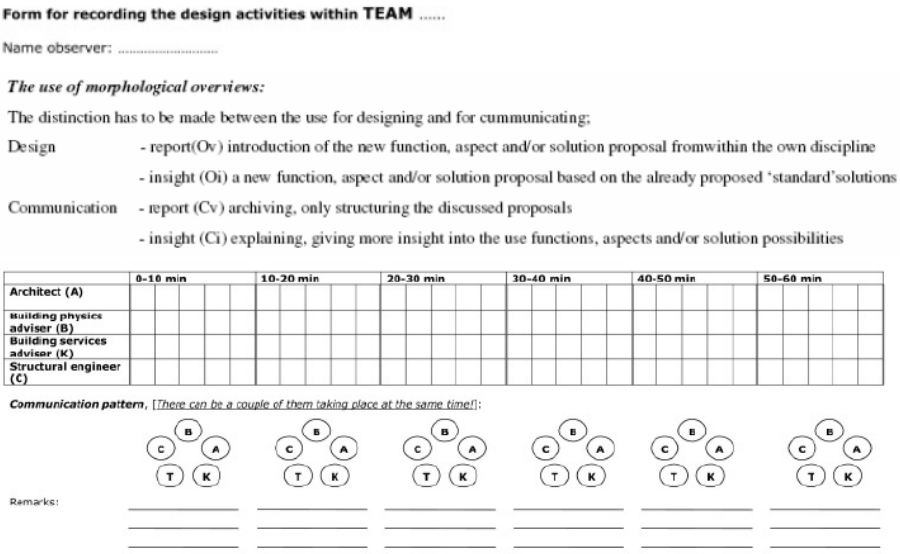
4.1 Observations

In the workshops the important link between practice, research and education (an essential part of the integral approach) was established through involvement of TU/e students. The students had the role of neutral observers, and were extensively instructed beforehand in order to be able to perform the requested observations. The type of activity, its occurrence in time and frequency were all registered. Through analysis of all results it was possible to evaluate the effect of the proposed approach.

Table 4. Student observations during the workshop series

2 students per same design team during the whole 3-day course					
communication		morphological overviews			
discipline to discipline	team	design		communication	
		report	insight	report	insight

During the workshop series the students were deployed per design team to observe different aspects of the design process. Two things were looked at: the communication between different disciplines and the use of morphological overviews. Both these aspects were observed by one student, with two students being deployed per design team. The students observed the same team during the whole duration of the workshop series. The main communication patterns during intervals of 10 minutes were registered. The communication could take place from one discipline to the other, or it could be team oriented. The morphological overviews could be used either for introducing design solutions or for the communication; both are discerned in reporting and in giving or acquiring insight.



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 cummunicating;

Design - report(Ov) introduction of the new function, aspect and/or solution proposal fromwithin 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) explaining, giving more insight into the use functions, aspects and/or solution possibilities

	0-10 min	10-20 min	20-30 min	30-40 min	40-50 min	50-60 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 2. The form the students were using for observations

4.2 Questionnaires

The design proposals and the amount of integration in designs can not be measured, therefore it was very important to hear how the participants experience the proposed approach and if they thought of it as beneficial. The only way to find out if this was the case was to get first hand information from the designers themselves. For this purpose various questionnaires were used, some of which were repeated after couple of months in order to assess if the proposed approach was used in the further daily practice of the participants. The participants were also asked to rate each others presentation results, in order to get some indication if the measurement results of the observed design processes matched the overall impression one gets of the consequent design processes results.

4.3 Photo's

To further verify the combined results from student observations and participant questionnaires, the design process was photographically captured every 10 minutes.

5. Results

5.1 Observations

The actual observations of design teams' activities provided the major and most important part of research data. Comparing practitioners (experienced professionals) and students (novice designers), one could see big differences regarding communication as well as use of morphological overviews (figure 5). The student teams showed much more difficulty in reaching some kind of shared understanding, leading to less team communication but at the same time to more intensive use of morphological overviews for communication purposes.

3-discipline teams comparison practitioners vs. students			Averages pract. vs stud.	
Communication:	1 on 1	arch ↔ consultants	42%	58%
		consultants ↔ consultants	13%	27%
	Team		45%	15%
Morphological overviews used for:	Design		71%	36%
	Communication		29%	64%

Figure 5. Comparison of observation results between practitioners' and students' 3-discipline design teams (arch stands for architect, con for consultant)

5.2 Questionnaires

Conducting questionnaires helped further evaluation of the use of morphological overviews. All student design teams consisted out of three disciplines. Because evaluation of the results from practitioners' workshops showed that number of disciplines within design teams is relevant [Savanović, 2006b], only the results from BNA-ONRI-KCBS workshop 3-discipline design teams were compared with the results of masters project student design teams.

Morphological overviews are relevant for: (on 1-10 scale)	Practitioners series 1	Practitioners series 2	Average practitioners series 1 &2	students	Differenc e%
Number of participants	24	19	43	25	
Response questionnaires in %	88	95	91	100	
number of alternatives	6,2	7,3	6,8	7,8	-14,7
team design process	6,8	7,6	7,2	6,6	8,3
contribution of 'others'	7,4	7,4	7,4	7,5	-1,4
communication	7,0	7,4	7,2	7,4	-2,8

Figure 6. Ratings of practitioners and students regarding the use of morphological overviews

The comparison with the results of student evaluations showed that students were generally more reserved.

	practitioners	students	Difference
Find proposed approach important	61%	52%	9%
Like working within design teams	76%	74%	2%
Expect to use morphological overviews	36%	50%	-14 %
Overviews beneficial for final proposals	43%	37%	6%

Figure 7. Percentage of positive reactions by practitioners and students respectively

5.3 Photo's: process progress

The work of design teams was also photographed, in 10 minute intervals. This way the development in time of the number of proposed alternatives was registered. Through the quantitative changes of the amount of proposed alternatives, generation activities of design teams could be followed. In figure 9 the average development of the number of generated alternatives by practitioner and by student design teams is shown.

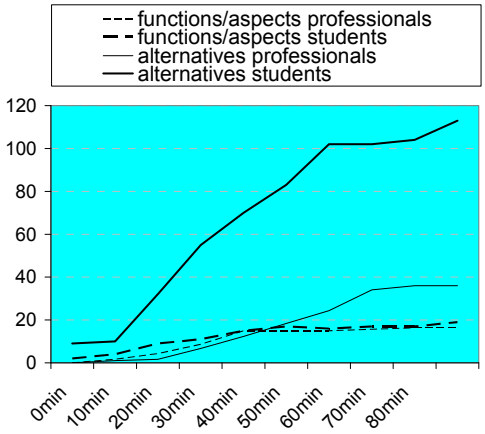


Figure 8. The number of produced functions/aspects and alternatives by practitioner and student design teams

On the Y-axis the numbers of defined functions/aspects by design teams are indicated. It is interesting to see that the total number of functions, which design teams defined as relevant for the design assignment, was similar for both practitioner and student design teams. The number of proposed alternatives and the way design teams generated them was, on contrary, completely different. The practitioner design teams tended to define functions first, and then to proceed with producing relevant solutions. This pattern was even more obvious with 4-discipline design teams [SAvanovic, 2006b]. Figure 8 shows however only the results of 3-discipline design teams.

The student design teams generated solution proposals and functions/aspects more simultaneously. Because the lack of development of shared understanding, represented by low amount of team-oriented communication (figure 6), the students tended to continuously generate new proposals while postponing the decision making. The experience of practitioners seemed to play an important role regarding this aspect of (conceptual) design. However, the amount of proposed alternatives by student design teams was much bigger, meaning that potential for discovering new (integral) solutions and combinations could have also been larger.

The quality of generated alternatives/proposals was not assessed. The aim was to only evaluate if use of morphological overviews would lead to the widening of 'field of possibilities' [Krick, 1969], which seems to be the case. Comparison between 3-discipline and 4-discipline practitioner design teams showed that this was even more evident within more complex design team configurations.

6. Conclusions

Based on the comparison between design teams consisting either out of experienced practitioners or out of master students, the following preliminary conclusions were made:

The practitioner design teams developed team communication faster than student design teams. This was not directly related to the use of morphological overviews, but to the design team arrangements. The observed 3-discipline student design teams acted the same way as 4-discipline practitioner design teams; they communicated internally more on a 1-on-1 basis using morphological overviews for communication purposes. From the observations was concluded that morphological overviews were

indeed helpful in structuring communication of student design teams. This statement was backed up by the results of various questionnaires that all participants were asked to fill.
Concerning design aspects of the use of morphological overviews, it was concluded that morphological overviews were helpful in structuring design activities of both practitioner and student design teams. They were also helpful in widening the field of relevant possibilities. Additionally, based on reactions from the participants themselves, morphological overviews were found to be relevant for use in both education and practice: they helped in communication within a design team configuration, they increased the number of relevant and new alternatives and they raised the awareness of contribution from other disciplines. However, majority of participants pointed out that these positive aspects did not necessarily mean that use of morphological overviews was always beneficial for the quality of (final) design concepts.

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