INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'09
24 - 27 AUGUST 2009, STANFORD UNIVERSITY, STANFORD, CA, USA

INTEGRAL DESIGN METHOD FOR CONCEPTUAL BUILDING DESIGN

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ABSTRACT
Building design processes show a sequential involvement of different responsible disciplines, where architects traditionally make designs while engineers optimize and make those designs buildable. However, most important decisions in building design are taken during early design phases, when building concepts are defined, making traditional approaches inadequate, especially for design of sustainable buildings that require new and innovative solutions. In order to enhance team design in conceptual design phase, an integral design method is proposed. This ID-method is meant to support creation of building design concepts by integrating discipline-specific object-design-knowledge, based on the 'knowledge space' and 'concept space' notions as explained by the C-K theory. The ID-method itself was designed through a series of 'learning-by-doing' workshops for experienced professionals, by iteratively adjusting both the method and workshop on basis of analysis and evaluations of the previous versions. The continuous development of workshops and the final design of the ID-method are presented in this paper. One of the main results achieved is the usability of the ID-method, indicated by workshop participants' positive comments and the inclusion of the method in the Royal Institute of Dutch Architects' Academy for permanent profession development.

Keywords: Integral design, Design teams, C-K theory, Design knowledge, Building concepts

1 INTRODUCTION
Building designs need to provide solutions for increasingly complex programs of requirements, especially related to sustainability issues ranging from flexible use to energy saving measures while maintaining and even increasing comfort level of the users, and therefore involve many experts from different disciplines. However, their traditionally sequential involvement, where architect designs and consulting engineers optimize and make those designs buildable, often hamper the development of new sustainable solutions. Besides, the different cultural background of architects and engineers, the former focusing first on synthesizing a solution and latter on analyzing the problem, hence their different approaches to design, present an additional complication. This causes inadequate cooperation between the different disciplines in the design process resulting, for example, in gaps between design and construction which translate into large failure costs. The estimation of the productivity loss in the Dutch building practice is about 8–10% of the total construction costs (€ 80 billion) per year [16].
The integral design method (the ID-method), developed from 2004-2008 at the Department of Architecture, Building and Planning of Eindhoven University of Technology [12,13], represents a specific translation of the broad notion of generally recognized need for integral approach in building design [10]. The main aim of integral design approach behind the ID-method was to improve conceptual design, both on process and product level, in order to increase the potential for creation of new sustainable solutions. Positive results at these two levels are expected to trigger and support the much-needed culture change in (Dutch) building design practice [17].
The dual interpretation of design, as process and product, reflects the two-fold aim of the ID-method. Firstly, the ID-method is meant to provide a framework for team design of integral building concepts during the early, conceptual design phase. The ID-method focuses on the conceptual phase because important decisions, the ones that have significant impact on possibilities for final sustainable design solutions and subsequent building construction, are taken then. Secondly, besides providing a framework to design integral design concepts, the ID-method is also meant for 'building' design teams. It is long known that teams in general require a certain amount of time to reach the so-called 'performing' stage [15]. In theory, a building design team could either evolve to this stage by doing a

number of projects together, or its members could be carefully selected and matched for each separate project. However, in (Dutch) practice, in case of team work building design teams are usually randomly configured and immediately after each project disbanded. Even though the different parties might repeatedly work together, one would never know which individual specialists were to form a project team. Furthermore, design teams tend to often change, largely due to long periods a building (design) project takes to complete. The ID-method tries to avoid both the time-consuming evolvement and arguably obsolete design team pre-selection stages by focusing on explication and integration of the available discipline-bound object-design-knowledge within a design team.
The main body of the paper starts with definitions (Section 2), after which the simultaneous development of workshops and the ID-method are explained highlighting evaluations of the workshop participants (Section 3). Next, the final ID-method design is summarized (Section 4). Finally, the paper ends with a short discussion of a possible ID-method use (Section 5).

2 DEFINITIONS

In order to understand integral approach behind the ID-method there are couple a-priori definitions that were used as a starting point and which need more detailed explanation: concepts and knowledge (Section 2.1), object design knowledge (Section 2.2), integral design (Section 2.3) and morphological overviews (Section 2.4).

2.1 Concepts and knowledge

The notion of design concepts is based on the C-K theory [3,5], which implies that all design concepts are necessarily new since they cannot be described by using only the existing design knowledge. The C–K theory defines design as the interplay between two interdependent spaces having different structures and logics, a process generating co-expansion of two spaces: space of concepts C and space of knowledge K. The structures of these two spaces determine the core propositions of C–K theory [4]:

- Knowledge: a piece of knowledge is a proposition with a logical status for the designer or the person receiving the design. Irrespective of the way in which this status is fixed, any form of logic, whether 'standard' or 'non standard', is in principle acceptable for a design theory. A set of knowledge is therefore a set of propositions, all of which have a logical status.
- Concept: 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'. Concepts capture the pragmatic notion of 'brief' or 'broad specifications' that can be found in innovative design.
- Space K: contains all established (true) propositions (the available knowledge, existing solutions).
- Space C: contains 'concepts' which are undecidable propositions in K (neither true nor false in K) about some partially unknown set of objects called a C-set.

A design concept is a proposition that cannot be logically valued in K. Concepts are candidates to be transformed into propositions of K, but are not themselves elements of K (properties of K can, however, be incorporated into concepts). If a proposition is true in K, it would mean that it already exists and all is known that is needed about it (including its feasibility). Design would then immediately stop. There is no design if there are no concepts. Without the distinction between the expansions of C and K, design disappears or is reduced to mere computation or optimization.

2.2 Object design knowledge

General design knowledge can be differentiated into three categories: object knowledge, realization knowledge and process knowledge [1, p.388]. Van Aken states that the repertoire of a designer typically consists of general object knowledge; knowledge of the characteristics and properties of artefacts and their material. As such, a designer produces representations of the artefact to be made; the object-design [1, p381]. These representations are regarded as the building stones for design concepts. On this basis it is assumed that individual designers explicate their object design knowledge by generating object-design representations driven by individual interpretations of the design task. This is the reason why, to name one of the ID-method assumptions, not the program of requirements should be regarded as a set of design criteria, but its interpretation by the designers.

The current need for innovative sustainable solutions for built environment means that new building concepts can only be created by integrating knowledge from different design disciplines. The use of word 'new' for building concepts is a bit ambiguous here, since according to the C-K theory concepts are per definition 'new'. As such, integral building design concepts can be considered preliminary design 'shapes' of a feasible sustainable building, created by a specialist design team covering at least the areas of architecture, building physics, building services, building technology and structural design. Knowledge of the listed disciplines is necessary if one is to call sustainable building design 'shapes' new, innovative and technically feasible. Other stakeholders in building design, such as clients, developers, managers and/or constructors might be able to either propose new and innovative ideas or to assess technical feasibility of concepts, but they are not able to transform ideas into concepts as design teams consisting of architects and engineering consultants are. Therefore, although they are often needed, these additional disciplines are not considered as part of building design teams.

2.3 Integral design

At this point it is useful to explain the differences between integrated design and integral design more explicitly. Within integrated design two or more disciplines are combined in order to become more effective. Within integral design all disciplines necessary and important are treated as part of, or contained within, the whole building design approach from the early stages of a project. To put it another way, within integrated design the architectural discipline and other disciplines start separately and often in different design phases and are later made to fit, whereas within integral design all necessary design disciplines start together right from the conceptual design phase.

During the early 1970s a prescriptive design model was developed in the Netherlands to teach design to mechanical engineering students at the University of Twente [8]. Called the Methodical Design model, it was based on the combination of the German (Kesselring, Hansen, Roth, Rodenacker, Pahl and Beitz) and the Anglo-American (Asimov, Matousek, Krick) design schools [9]. The Methodical Design model makes distinction between phases and levels. The three main phases distinguished are: problem definition phase, working mode definition phase and form giving phase. The discerning of levels is based on a hierarchy of complexity. The Methodical Design model makes it this way possible to link different abstraction levels with the phases in the design process, while maintaining the basic three-step design cycle (analyse / synthesize / evaluate) recognizable within each phase. This familiar model (in the Netherlands) was extended by Zeiler [19] with an additional selection step focusing on the decision making that has now become more explicit compared to the Methodical Design model. However, the main difference of both the original and extended Methodical Design models in relation with other familiar models [18] is 'shaping': when compared with more widely known models, for example the basic design cycle of Roozenburg and Eekels [11] (analysis, synthesis, simulation, evaluation and decision), the difference appears to be in the implementation and shaping of the design into lower levels of abstraction. The focus is on the connection between the 'horizontal' and 'vertical' dimensions of design process modelling.

2.4 Morphological overviews

A distinctive feature of the extended Methodical Design model is the use of morphological overviews for separate design activities. Morphological overviews originate from the n-dimensional morphological box [20]. The two-dimensional form of the Zwicky's box is usually referred to as 'morphological charts' [7, p.292]. The typical individual designers' use of morphological charts requires all design functions to be defined and all possible solutions for each function to be listed, resulting in the framing of solution space. However, because instead for 'straightforward' problem-solving the main use of the ID-method is for exploration of 'new' concepts, the essentially two-dimensional matrix representations of the Zwicky's box are called morphological overviews within integral approach. They provide overviews of possibilities from all disciplines involved in team design, based on subjective interpretations of the design task. Although the construction of overviews is same as matrices, with on vertical axis main design aspects and on horizontal axis possible solutions for each aspect, the design team interpretation is the key. The completeness of the design is based on the essentials as determined by different disciplines within the design team. The purpose of the vertical list is to try to establish the aspects that according to the design team should be incorporated in the product, i.e. essential functions that the design has to fulfil.

3 INTEGRAL DESIGN WORKSHOPS

As other research fields show, using human subjects as study objects in laboratory experiments can provide valuable insights [2]. However, generalizing the results from experiments entails a certain risk. The real-world setting requires activities in ways that artificial settings can rarely simulate. Schön [14] proposes a practicum as a means to 'test' design(ing), where a practicum is 'a virtual world, relatively free of the pressures, distractions, and risks of the real one, to which, nevertheless, it refers.' [14, p.37]. In Schön's practicum a person or a team of persons has to carry out the design. A practicum can asses a design method and the degree to which it fits human cognitive and psychological attributes [2].

A workshop can be seen as a specific kind of practicum. It represents a self-evident way of working for designers that occurs both in practice and during their education. As such, a workshop provides a suitable environment for testing the desired approach. Besides full design team line-up there are a number of other advantages of workshops with regard to standard practice situations, while at the same time retaining practice-like characteristics as much as possible: workshops make it possible to gather a large number of professionals in a relatively short time, repetition of the same assignment and comparison of different design teams and their results.

The workshops for testing the ID-method and integral approach were organized in cooperation with the Royal Institute of Dutch Architects (BNA) and the Dutch Association of Consulting Engineers (ONRI), meaning that all four earlier mentioned building design disciplines participated: architects, structural engineers, building physics and building services consultants. All workshop participants were experienced professionals and members of either BNA or ONRI. Since 2005 a total of five workshops were organized, in four different configurations. The last configuration was conducted twice in order to provide more comparison material and double check the outcomes with different groups of designers.

3.1 Workshop 1, the first experimental configuration

The first workshop lasted three ½-days of four hours each, and was conducted on May 31st, June 7th and 14th 2005. Each ½-day had two 60-minutes design sessions for design teams consisting of architects, structural engineers, building physics and building services consultants.

3.1.1 Workshop aim

The main aim of the first workshop was to try if it was possible to use morphological overviews in design teams to expand the production of (sub) solutions to all involved disciplines by following the four step pattern of the extended methodical design model.

3.1.2 Workshop setting

A total of 24 professionals participated during the three days: 5 architects, 6 structural engineers, 5 building physics consultants and 8 building services consultants. They were randomly assigned to 5 design teams, each team having at least one participant from each design discipline. The teams worked separately on same design assignments. The number of architects determined the number of design teams; the same formula was also used for other four workshops. Since the workshop was spread over three consequent, in this case Tuesdays, there were inevitable changes in team configurations. A number of participants were not able to attend all sessions and often sent replacements. Finally, 11 out of 24 participants were able to take part in all design sessions: 4 architects, 1 structural engineer, 4 building physics consultants and 2 building services consultants. However, these team changes had no negative influence for the research setting since the focus was on getting initial response on use of morphological overviews, rather than comparing design processes and design teams.

The first day was essentially meant for teams to practice working with morphological overviews. After explanation on the used integral approach the teams were given a design task 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 first day sessions the teams had to give short presentations to each other about their design concepts. The second and third day where more structured. The four steps of the extended design model where to be strictly followed by the design teams. The teams were given a new design task, to design a zero-energy multifunctional office building on a standard Dutch location, and for each step they had to use morphological overviews. Two design sessions on the second day where

used for interpretation of the design task and generation of possible sub solutions. On the third and last day the teams had to choose suitable solution (combinations) during the first design session and to integrate them into concepts during the second and last session.
All participants were given questionnaires at the end of the third workshop day and asked to fill them again approximately six months after the workshop. A selection of results from the first workshop is shown in Table 1. Besides participants' questionnaires, the research data was also acquired in three other ways: through direct observations of design teams' activities (taking notes on predefined forms), by taking photographs of team work each 10min, and by gathering all produced material for detailed analysis. Later, for last two workshops, video recordings were used as well as means of capturing data.

3.1.3 Workshop results

Although rich research data was acquired and analyzed, in this paper only the evaluations from participants are further discussed since the reactions from participants were considered vital in assessing the acceptability and usability of morphological overviews by and for professionals in practice.

Table 1. Participants' evaluations of workshop 1

Questions:	Directly after [94% reactions, 16/17 of last-day participants]	After 6 months [73% reactions, 8/11 of all-days participants]
1. Workshop rating	7,8 out of 10	8,0 out of 10
2. Importance of approach for practice / in last 6 months	7,8 out of 10	4,8 out of 10
3. MO's relevance for practice	7,4 out of 10	6,5 out of 10
4. Need to stimulate MO's use	6,7 out of 10	6,5 out of 10
5. Expected MO's use / actual MO's use in last 6 months	6,6 out of 10	5,0 out of 10
6. Importance of workshops for professionals' education	9,0 out of 10	9,5 out of 10

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 the proposed approach; during the 1st day almost 1/3 thought of it as not relevant for their practice, and at the end of the 3rd day none had negative view on it. It showed the importance of the 'learning-by-doing' workshop configuration. Regarding evaluations, the reactions after the six months were curious since the workshop and its importance for professionals' education were rated even higher than immediately after the workshop (while other aspects got lower scores). The main reasons provided by the ones that tried but not succeeded in using the approach and morphological overviews for real time projects where: 'stuck in ongoing projects' and/or 'unable to use morphological overviews with new parties'. The last remark could be traced back to the fact that during the workshop it was observed that designers often tended to combine interpretation/generation and generation/selection steps, making it sometimes difficult to understand what they aimed for with some actions.

3.2 Workshop 2, the second experimental configuration

For the second workshop the formal role of the client was introduced during the first session of the third workshop day. The second workshop lasted again three ½-days of four hours each, and was conducted on October 24th, 31st and November 7th 2005. Each ½-day there were two 60-minutes design sessions with design teams consisting of architects, structural engineer, building physics and building services consultants. There was also one project manager that asked to be allowed to participate as well.

3.2.1 Workshop aim

The main aim of the second workshop was to emphasize the learning effect of using morphological overviews by formally introducing a third party, the client, during one of the extended methodical design model steps. The idea was to 'force' the design teams to at least more explicitly present the outcomes of different steps, even though the designers would still combine the activities into one.

3.2.2 Workshop setting

This time a total of 19 professionals participated during the three days: 6 architects, 1 structural engineers, 1 project manager, 5 building physics consultants and 6 building services consultants. Out of 19 participants 14 took part in all design sessions: 4 architects, 1 structural engineer, 4 building physics consultants and 5 building services consultants. Besides the clients' role, the biggest difference with the previous workshop was the absence of structural engineers and presence of a project manager, which resulted in different typed and sized design teams.

3.2.3 Workshop results

Morphological overviews were differently used within different-sized design teams; four-discipline teams used them generally more for communication purposes than 3-discipline teams [12].

Table 2. Participants' evaluations of workshop 2

Questions:	Directly after [100% reactions, 17/17 of last-day participants]	After 6 months [50% reactions, 7/14 of all-days participants]
1. Workshop rating	6,7 out of 10	6,6 out of 10
2. Importance of approach for practice / in last 6 months	8,2 out of 10	6,0 out of 10
3. MO's relevance for practice	7,6 out of 10	6,9 out of 10
4. Need to stimulate MO's use	7,2 out of 10	6,9 out of 10
5. Expected MO's use / actual use in last 6 months	6,1 out of 10	4,0 out of 10
6. Importance of workshops for professionals' education	7,6 out of 10	7,4 out of 10

For evaluation of participants the same questionnaires were used during all five workshops, which made comparison of outcomes possible. The most striking difference with the previous workshop was in the rating of the workshop and the perceived importance of workshop for professionals' education, both directly and after six months. The introduction of the client's role proved to be a step too far, which actually disrupted the process. Just as the involvement of project manager was insignificant, the participants did not feel the need for client contact during the process. However, the fact that BNA and ONRI representatives acted as clients (for a practice-based, but not real project in practice) might have caused these reactions. It seemed that use of morphological overviews as a basic tool for structuring design process was big enough change for participants in that short amount of time. The most positive result was the improvement in reactions towards the importance of the approach for practice; although the analysis and workshop setting were not prepared to assess this point, it could be that explicitly dealing with a third party highlighted the advantages of a transparent and structured approach.

3.3 Workshop 3, third experimental configuration

While the decision was made to drop the client role completely and focus entirely on the use of morphological overviews, in order to enhance internal learning effect a stepwise changes from traditional building design setting towards the ID-method were introduced. The third workshop retained the three ½-days length, but the length of design sessions was changed. Since traditionally design activities do not start in team setting, the first day dictated that all first design sessions during all three days where shortened to 30 minutes in order to leave more time for team activities. In order to preserve the total amount of design time the same, all second sessions during all three days where accordingly prolonged to last 90 minutes.

3.3.1 Workshop aim

The third workshop was conducted on June 12th, 19th and 26th 2006. The aim of the workshop was to focus on internal learning effect within a design team; just as a design team recognized the need to present their work to third parties, they needed to experience that the same is required for knowledge transfer between design disciplines within a design team itself.

3.3.2 Workshop setting

The workshop started with a traditional setting, meaning that only architects worked on a design task during the first session of the first workshop day. For second session design teams were formed that had to continue to work on the same task using the initial interpretations of the architect. On second day participants started working immediately in new teams during the first session, creating context for shared interpretation of a new design task – the first change to the traditional building design. During the second design session final solutions had to be produced. On last day again new teams had to work on third design task using morphological overviews – the second change to the traditional building design. During all three days the first session was meant for interpretation/generation activities and second for generation/integration. A total of 23 professionals participated during the three days: 7 architects, 3 structural engineers, 6 building physics consultants and 7 building services consultants. A total of 20 out of 23 participants took part in all design sessions: 6 architects, 3 structural engineer, 6 building physics consultants and 5 building services consultants.

3.3.3 Workshop results

The workshop configuration allowed for clear comparison between different processes. It was also the first time that comments from the participants during the workshop indicated effectiveness of the 'learning by doing' setting. Constantly changing teams added to creation of good working atmosphere. Enthusiasm was clearly higher than during previous workshops, resulting in less drop outs.

Table 3. Participants' evaluations of workshop 3

Questions:	Directly after [95% reactions, 19/20 of last-day participants]	After 6 months [70% reactions, 14/20 of all-days participants]
1. Workshop rating	6,6 out of 10	7,0 out of 10
2. Importance of approach for practice / in last 6 months	6,6 out of 10	6,3 out of 10
3. MO's relevance for practice	6,4 out of 10	6,4 out of 10
4. Need to stimulate MO's use	6,4 out of 10	6,7 out of 10
5. Expected MO's use / actual use in last 6 months	5,3 out of 10	3,6 out of 10
6. Importance of workshops for professionals' education	7,6 out of 10	8,7 out of 10

However, the participants felt that workshop abruptly ended, without feedback on the main theme: working with morphological overviews. The tool was actually not assessed, because participants were mainly busy understanding its use. This partly explains higher scores after six months for questions 1 and 6 (Table 3). The conclusion was that introduction of a new tool should not happen during the last day; since it's new, participants need time to adapt and rightfully demanded feedback. It meant that the workshop setting required additional design sessions.

3.4 Workshop 4 and 5, fourth and final experimental configuration

A new workshop configuration was defined that consisted out of four experimental settings, performed during two full days. Each working day lasted 8 instead of previous 4 hours, increasing the total length of design sessions from 6 to 8 hours. This change was needed because it was not possible to add new design sessions in the previous three ½-day settings.

3.4.1 Workshop aim

The aim of the new workshop setting was to provide as smooth transition as possible from traditional to team design. Besides two main changes, namely simultaneous start by all disciplines and the use of morphological overviews in a design team setting, a possibility for an individual learning cycle was introduced. In order to be able to effectively apply a new approach, one has to first understand it, make it his own [7]. Although we believe that this is also possible to achieve within a design team setting, the previous attempts showed/confirmed that longer periods of time are needed for this type of team evolvement to happen. However, as pointed in the introduction, the ultimate aim of the ID-method was to avoid both the time-consuming evolvement as well the obsolete design team pre-selection stages by focusing on explication and integration of the available discipline-bound object-design-knowledge

within a design team. For this purpose the most effort was directed on testing if morphological overviews were a suitable tool for this task, which the reactions from participants of all three previous workshops actually confirmed (see ratings for questions 3 and 4 in Tables 1-3).

3.4.2 Workshop setting

There was a clear distinction made between day one and two in that only during the second day participants worked with morphological overviews. Compared to previous workshop configuration, the first and third day of the old configuration were expanded with an additional design task each, which effectively replaced the previous second day. There were in total four design sessions per day in new configuration. The new first two sessions of day one remained the same as the two sessions of previous workshop day one. The change was that during the third session participants from all disciplines started working simultaneously, but separately from each other, on a new design task. In the fourth session they were joined in design teams. The same formula was repeated during the first two design sessions of day two, again using new design task, with the notable difference that this time participants were to use morphological overviews. This provided opportunity to work individually with morphological overviews in session one, before subsequently trying them out in team settings during session two. The final, fourth design task was to be tackled in the last two design sessions, which were the same as the two sessions of day three in the previous workshop configuration.

A total of 24 designers participated during the workshop 4, the first two-days-workshop that was conducted on May 15th and 22nd 2007: 9 architects, 1 structural engineer, 6 building physics consultants and 8 building services consultants. At the end 16 out of 24 designers took part in all design sessions: 6 architects, 6 building physics consultants and 4 building services consultants. There were also 6 other disciplines involved: 2 project leaders, 2 project managers and 2 developers. Only two of them took part in all eight design sessions: 1 project leader and 1 developer. Regardless, based on previous experiences their evaluations were not to be taken into consideration.

The last workshop configuration proved to be successful and the workshop was again repeated on February 5th and 12th 2008, where a total of 19 professionals participated: 5 architects, 3 structural engineers, 4 building physics consultants and 7 building services consultants. A total of 14 out of 19 participants took part in all design sessions: 5 architects, 3 structural engineers, 2 building physics consultants and 4 building services consultants.

3.4.3 Workshop 4 results

The two-day instead of three-day workshop configuration was a major improvement. With changes in workshop configurations the main objections from previous workshop, lack of feedback and the abrupt ending of workshop, were removed. The participants also got the impression that more time was dedicated to the 'main issue' of working with morphological overviews. The transition from traditional to integral design setting proved indeed to be smooth enough.

Table 4. Participants' evaluations of workshop 4

Questions:	Directly after [95% reactions, 21/22 of last-day participants]	After 6 months [56% reactions, 9/16 of all-days participants]
1. Workshop rating	6,7 out of 10	6,7 out of 10
2. Importance of approach for practice / in last 6 months	7,6 out of 10	5,1 out of 10
3. MO's relevance for practice	7,8 out of 10	5,8 out of 10
4. Need to stimulate MO's use	7,9 out of 10	6,2 out of 10
5. Expected MO's use / actual use in last 6 months	6,9 out of 10	4,0 out of 10
6. Importance of workshops for professionals' education	8,3 out of 10	7,8 out of 10

However, the participants showed clear preference for the third design setting: starting individually working with morphological overviews, then moving on to design team configuration. The last design setting was, even beforehand (!), seen as needless by the participants. After the third design task the majority of participants agreed that this should be the optimum formula and were even a bit reluctant to proceed with the fourth and last design setting. The reasoning before and after the last two design

sessions was that they felt that in within design teams there is always somebody who takes the lead leaving less assertive team members no chance to let their voice be heard. Using morphological overviews to separately interpret design task and propose solutions from one's own perspective, and actually put it on paper for discussion solved these problems. Although it was rewarding to hear that participants regarded the proposed approach worthwhile, the failure to make obvious to them the impossibility of having an optimal process in practice, as for example the situation simulated during the third design task, and therefore the necessity of mastering the situations as in the last design setting was disappointing. It was interesting to observe that 'other' disciplines (managers, developers) were the most vocal regarding the above explanations. However, it can be argued that the results from the 'after-six-months-evaluation' (Table 4), where they did not participate, reflected the same frame of mind of the four building design disciplines.

3.4.4 Workshop 5 results

The reactions on workshop 4 suggested that the last, and from integral design point of view most important design setting, was obsolete. In order to test these results the workshop was repeated, but without the participation of 'non-design' disciplines.

Table 5. Participants' evaluations of workshop 5

Questions:	Directly after [94% reactions, 15/16 of last-day participants]	After 6 months [71% reactions, 10/14 of all-days participants]
1. Workshop rating	7,7 out of 10	6,8 out of 10
2. Importance of approach for practice / in last 6 months	7,5 out of 10	5,2 out of 10
3. MO's relevance for practice	8,0 out of 10	6,8 out of 10
4. Need to stimulate MO's use	8,2 out of 10	8,0 out of 10
5. Expected MO's use / actual use in last 6 months	7,2 out of 10	4,4 out of 10
6. Importance of workshops for professionals' education	8,9 out of 10	8,6 out of 10

It turned out that the average ratings were never before as high and none of the participants mentioned the possible redundancy of the last design setting, which was a big issue during the previous workshop. Seen in retrospective, this might just have had to do with the influence of other 'non-design' disciplines involved in design sessions during the previous workshop. Comparing the results in Tables 4 and 5, the biggest difference can be seen regarding question four. After six months the participants thought that it was needed to stimulate use of morphological overviews, even though they actually did not manage to use them in practice. Our interpretation is that it shows they still value the possibility of its use in random design team settings.

4 RESULTING ID-METHOD

Based on afore explained theoretical background and empirical findings, the resulting ID-method can be summarized as a design method for design teams in building design conceptual phase whose aim is to enhance creation of integral design concepts using morphological overviews as design tool through:

1. interpretation of the design task, resulting in lists of functions/aspects arranged
    a. design team interpretation, or
    b. design discipline interpretations, followed by (1a)
    c. individual designer interpretations, followed either by (1b)+(1a) or directly by (1a)
2. generation of possible solutions, resulting in overview of the available 'object-design-knowledge'
    a. individual generation of sub solutions per function/aspect
3. combination of generated sub solutions, resulting in redesigns (Figure 2), and/or integration of generated solutions, resulting in integral design concepts (Figure 3)
    a. design team merging of discipline-based object-design-knowledge
    b. design team transformation of discipline-based object-design-knowledge
4. determination of directions for next design phases
    a. design team optimization of redesign gradually leads to detailed solutions on lower abstraction levels and finally results in knowledge transfer between design disciplines

b. design team evaluation of integral design concepts defines specific development areas which can eventually result in creation of new object design knowledge

Steps 1 and 2 can be taken simultaneously, as designers tend to produce and evaluate solutions at the same time, something that was observed in all five workshops. As shown in Figure 1, all kinds of iterations are possible. This is where added value of morphological overviews' structuring is most apparent. External feedback can take place after each step; by using morphological overviews external parties can transparently look if according to them all necessary functions and aspects are dealt with.

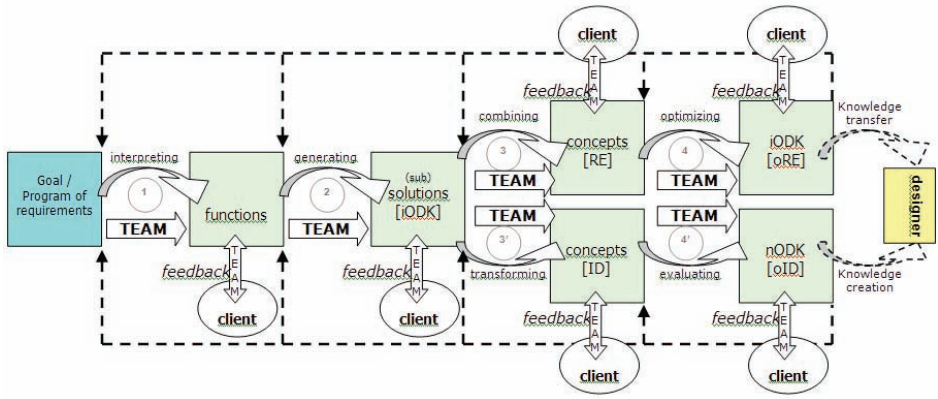

Figure 1. The ID-method steps

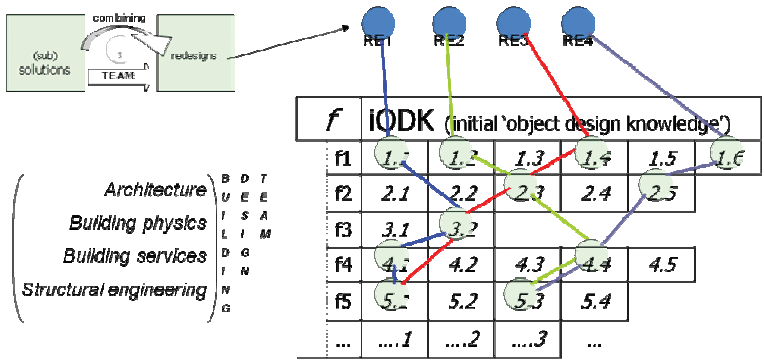

Figure 2. The ID-method step 3

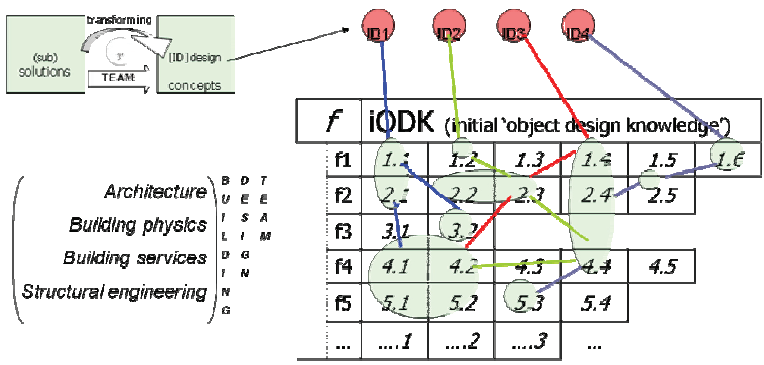

Figure 3. The ID-method step 3'

5 DISCUSSION

Integral design concepts are only possible by starting together and uniting various viewpoints of the different design disciplines participating in the project. In order to achieve not only integration but also true synergy between all disciplines a single designer has to 'force' him or herself to consider different discipline-based viewpoints while designing. Even if a designer has the ability to deploy most of these viewpoints, he or she usually does not have enough specialist knowledge to assess all of them in depth. For this reason it was assumed that a multi-discipline design-team-view on design is a better way of pursuing building design integration than a mono-discipline individual-designer-view.

Design within our integral approach represents realization of potential for creation of new object-design-knowledge through integration of discipline-based explicit object-design-knowledge into integral design concepts. Working with morphological overviews forms the basis for supporting the creation of conceptual ideas. The overviews explicate and structure the communication between design team members and stimulate multidisciplinary knowledge exchange to be implemented in building designs. By analyzing if the proposed ID-method for building design teams enhances emergence of integral design concepts, one could say if (within specific context of a particular design team) potential for creation of new object design knowledge is realized. This potential increases the possibility of arriving to 'satisficing' final solutions in subsequent design phases of a given situation. The number of integral design concepts produced by design team is then the measure for this potential. In order to confirm effectiveness of the ID-method, a number of hypotheses need to be tested:

1. simultaneous involvement of building design disciplines on a design task results in more (considered) design functions/aspects;
2. additional application of morphological overviews transparently structures design functions/aspects, resulting in more (sub)solution proposals;
3. formation of multidisciplinary design teams at the very beginning of preliminary design phase results in creation of integral concepts;
4. creation of integral design concepts will not happen (if at all) before the last design setting.

In last workshop configuration the first design setting is meant to provide reference values, the second for testing the first hypothesis, the third for testing the first part of the second hypothesis and the fourth for testing of the second part of the second hypothesis, as well as hypotheses three and four. In order to test the second part of the second hypothesis a full learning cycle regarding use of morphological overviews is needed. The last hypothesis is also meant to confirm the need of an individual learning cycle. The crucial element of the workshop configuration is the design team arrangement. To compare different types of design processes, the usual solution would be to use 'matched design teams'. However, besides the fact that this is something that has no resemblance with practice, it requires large number of instances in order to, in any way, be able to generalize the results. The alternative solution is not to observe the same design teams during all four design settings, but to compare the average results of each design task while changing design team's arrangements. This approach would in our case result in different teams for each assignment, but they would be consisting out of the same group of participating designers. The only rule to be obeyed is that two designers can be in the same team only once. The difference between the first and the last two workshop configurations should clarify the approach. The first two workshop configurations can be used to compare average results of different workshop days, but only for different activities within the same type of design processes. The last two workshop configurations can however be used for comparison of same activities within different types of design processes. The final remark would be that the sequence of design settings is of utmost importance, reverse or mixed order of the last workshop configuration is not possible.

The already acquired positive results from the BNA-ONRI-KCBS workshops, based on the in this paper partly presented evaluations of the workshop participants, where the reason for BNA to include the ID-method in the Royal Institute of Dutch Architects' Academy for permanent profession development. The ID-method course will be facilitated by the Dutch Society for Building Services (TVVL) and will start in second half of 2009.

ACKNOWLEDGEMENT

The Knowledge Centre Buildings and Systems (KCBS TU/e-TNO), Kropman bv and the Foundation 'Stichting Promotie Installatietechniek' (PIT) supported this research.

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