

WORKSHOPS 2005-2008 FOR THE DUTCH BUILDING INDUSTRY: COLLABORATIVE ENGINEERING

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ABSTRACT

In the Dutch Building Industry sub optimal use of knowledge by participant during the design- and engineering phase causes building damage and hinders innovative designs and solutions. First experiments to find a format for supporting Design Collaboration, started in 2004 with workshops for design- teams including participants with the same educational background. In 2005, a first set up was done for design teams with participants with different educational backgrounds. These workshops are coupling a concrete task from practice and research focusing on the roofs where there is a lack of innovative designs, caused by a sub-optimal interaction between solutions and application in design practice. The process where actors from different disciplines work together to develop a (new) product is called Collaborative Engineering (CE). Workshops are used to offer a collaborative context to professionals and to determine in steps an adaptive method to analyse and improve the design collaboration related to knowledge exchange.

From 2005 until now 5 workshops for students and professionals were done. This paper describes the development of the workshops with the focus on the development of the workshop setting.

Keywords: collaborative engineering, building industry, workshops

1. INTRODUCTION

Roofs play an essential role in buildings. Their value and impact often significantly surpass the cost ratio they represent in the total investment cost of the building. Traditionally, roofs have a protecting function and their basic design has changed little over hundreds of years. Nowadays however, they are increasingly used as preferred location for mounting additional functions such as photovoltaic systems, roof lights, ventilation devices, insulation and safety devices. The roof will contain more and more aspects that are strongly related with the comfort of the building as a whole. Looking in a wider context, the build environment is dominated by the circumstances related to energy use. As results of Global Warming become more and more prominent, it is necessary to look for new ways to save more energy and to generate more sustainable energy for the comfort in the building environment [1, 2, 3]. In current building design primarily the façade, as the most prominent building component, is used as integral part of these sustainable comfort systems. This integral approach is lacking for the roof, where these systems are mostly treated like add-on components to the already completed conceptual building design.

The actual state is that there is a gap exists between solutions and application in design practice of active roofs [4]. Roof design and roof engineering with all its existing – traditional – and new functions and applications are most of the time handled like separate and add-on aspects. As complexity and scale of design processes in architecture and in building services engineering increase, as well as the demands on these processes with respect to costs, throughput time and quality, traditional approaches to organize and plan these processes may no longer suffice [5, 6, 7, 8]. Also responsibility changes; the role of the main contractor moves to that of coordinator, the responsibility of the sub-contractor and therefore the co-operation with fixed partners – like collaborative engineering – will develop [9].

In the future, the sub-contractor – the roofer – will not be chosen on the basis of price, but more and more on quality and long period partnership. Increasing their own knowledge and skills and organize strategic alliances in order to offer a more innovative quality is therefore necessary [10]. Although there is specific knowledge, within the roofer industry, concerning how a roof must be made, the roofer should be more active and anticipating on these developments. The added value of this knowledge should be incorporated on the right moment of the design. In the concept phase of the building design the most important decisions have to be made in order to optimise the final result. At this stage of the process many of the construction- and user-aspects should be implemented in order to optimise the final building product and to reduce failure costs and damage to the roof, during the user phase (Fig. 1).

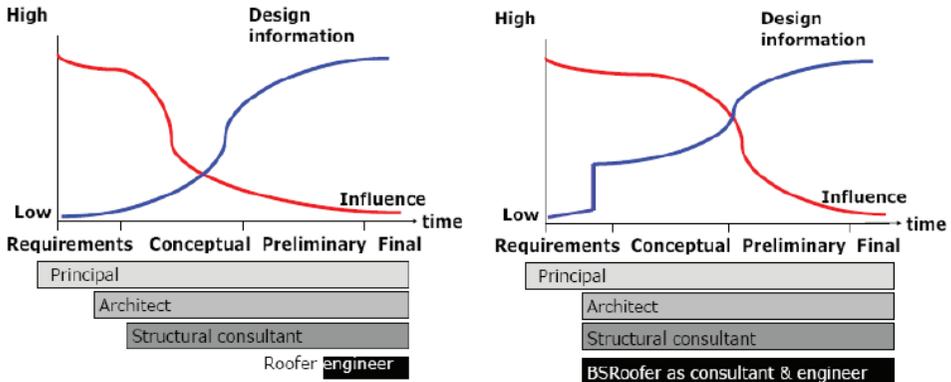


Figure 1: The influence of design information through time of the design process (requirements, conceptual, preliminary and final phase) related to the position of the different disciplines; left side the current situation for architects and roofer – engineer; right side the setting of collaborative engineering (CE) which can improve the necessary design-information needed in the primal phase of the design.

The process where professionals from different disciplines work together to develop a (new) product is called Collaborative Engineering (CE). Within this setting actors have different cultural backgrounds, way of working, different motivation of collaboration and geographical conditions. The workshops are used as Collaborative Engineering settings for professionals. The supportive process approach that is introduced in the workshops to develop a more optimal design and product is the Integral Approach. An Integra Approach can improve the conceptual design (process level) in order to increase the potential for creation of more integral design concepts (product level). The Integral Approach means a design approach where all necessary information and knowledge from different disciplines (architects, engineers, constructors), with aspects from different levels of abstraction and with different representations, is synthesised to generate optimum design proposals for the specific context. Design can be considered a problem solving activity where the need transformed to a design problem and its solutions co-evolve. To design is to formulate a product model taking into account; the objectives to be achieved, the available resources and the prevailing boundaries.

Supporting design teams with a design method, which can incorporate the characteristics of the integrated product model, can lead to more optimal designs. The aim of introducing this design method is to support design activities within this highly complex process with a framework for structuring the design process by structuring the information and knowledge exchange, between and with commitment of all participants, within the design process. This method – Morphological Overviews (MO) – is derived from the Morphological Charts as developed by Zwicky and Norris [11]. Research on Integral Design in practice with professionals, both for development and evaluation, is ongoing from the year 2000 through the study Integral Design (an initiative from the Royal Association of Dutch Architects (BNA), the Dutch Society for Building Services (TVVL) and Delft University of Technology (TUD)) [12]. From 2004 a new research started within the Knowledge Centre Buildings and Systems (KCBS), in which Eindhoven University of Technology (TU/e) and the Netherlands Organization for Applied Scientific

Research (TNO) cooperate. Both researches use(d) the Integral Approach in their way of handling and looking to the specific contexts; through different views on the same subject – collaboration between disciplines with different backgrounds- insight can be generated. These studies resulted in ongoing workshop series, in which already over 250 professionals from BNA and the Dutch Association of Consulting Engineers (ONRI) participated, used for development and evaluation of Integral Design and the design method of Morphological Overviews [13].

The developed workshops appear to be effective and adaptable environments for professionals to work / design in team-settings and as research situation to evaluate and develop the proposed design-method of Methodical Design and Morphological Overviews. Until now the workshops were organized for design-team-members with the same educational background. The workshop as proposed in the setting of EURACTIVE ROOFer focuses on the situation of Collaborative Engineering, where participants with different educational backgrounds work together; roofer and architect. This paper describes step by step the development and used research method of a new series of workshops within the context of the Dutch Building Industry for collaboration between architects (designers) and roofers (constructors / engineers) in the early design phase. The paper will conclude with the find set up for the optimized adapted workshop setting, for workshops to be held in 2009.

2 DESCRIPTION OF THE DEVELOPMENT OF THE WORKSHOP-SETTING

The integral approach means different viewpoints on the same topic. For this research the two main viewpoints are that of the designer – the architect – and the constructor – the roofer. The focus for the Workshop is on the explicit knowledge used by the roofer and architect in the early phase of the design, as most important decisions are made in this phase in relationship to cost and risks during the construction and user phase of a building. Related to the roofer we define this as realization-knowledge and of the architect as object or design-knowledge, both will also have knowledge of the other ‘field. Important for the usefulness of the workshop is that participants must have enough experience in realized projects. In relationship with knowledge sharing and knowledge development in the early design phase, this means that both roofer and architect have also process-knowledge [8.]. To organize the development of the Workshops first the different viewpoints were defined.

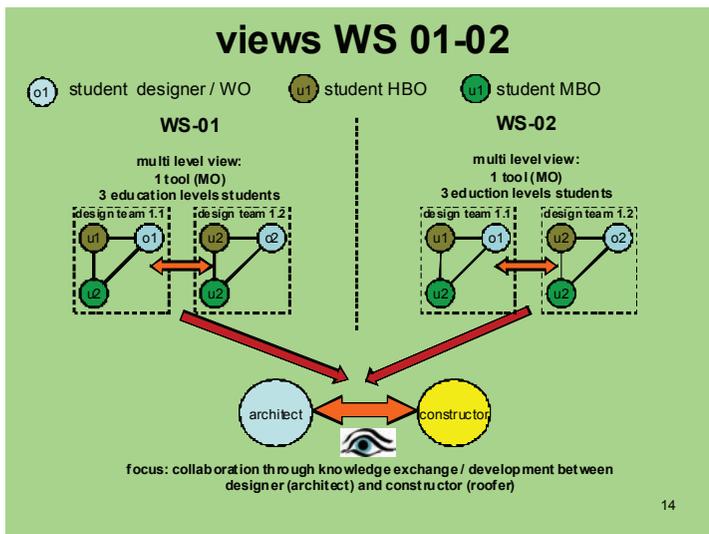


Figure 2: Step 1: different views on the same topic with students = outside Dutch building practice; collaboration between architect and constructor by students with three different levels of education, university (WO) and HBO and MBO; two multi level workshops WS 01 and WS 02 as organized in 2005 and 2006.

First step was to research view from outside the context of the Dutch building industry practice by using the education context. This education context we used to determine how the differences between object- and realization knowledge of architect and constructor / engineer were experienced by students with three educational levels. The university level (WO) educates at the highest level of abstraction and is more focused on object-knowledge were HBO and MBO are levels on education more focused on realization knowledge. The HBO level students however have also some education in object knowledge (see Figure 2).

The design method of Morphological Overviews (MO) was used to gather information about the experience of using a tool by students with different education levels. The setup was as following (see Figure 3); team 1.1 with each one student of a education level worked first without the MO and then after changing the team with MO. After the final presentation the results and way of working was evaluated by the participants. In this paper only the most important conclusions are given which are of importance of the second step; the workshops for professionals.

Positive results WS 01 / WS 02:

- We were able to observe the intensity of communication and design within the different team members
- Through questionnaires we could get insight in how students with different educational background experienced working together as part of Integral Design

Negative results WS 01 / WS 02:

- Monitoring of communication was only done with format, therefore some aspects of the interaction could not be identified and analysed

Conclusion [to take into account for next workshops]:

- Monitoring format needs improvement in order to observe more precise interaction and use of MO; too much participants in one team to monitor clearly; focus on architect and constructor / engineer
- Analyses of results needs improvement; develop a validated method; combination of monitoring and analysing methods.

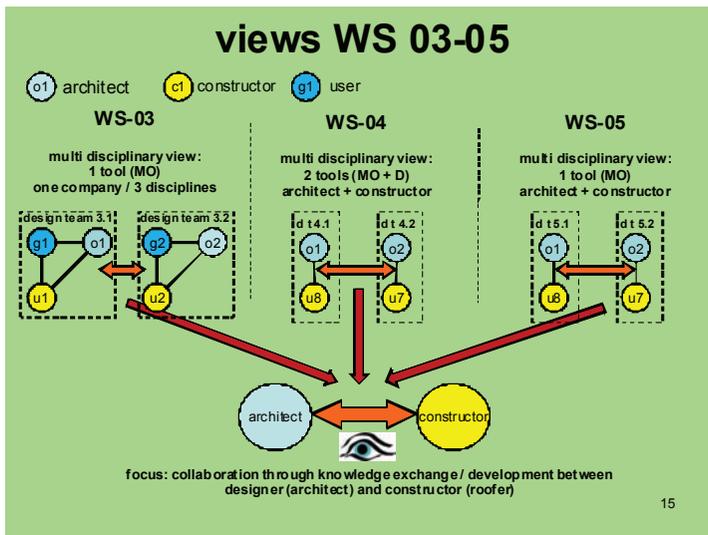


Figure 4: Different views on the same topic with professionals; collaboration between architect and constructor by professionals; WS 03 with multidisciplinary view with users with use of 1 tool (MO), WS 04 multidisciplinary team with architect and roofer with use of two different design methods(MO and Database), WS 05 multidisciplinary teams with architect and roofer with one tool as design method (MO).

The second step for the research is the view from inside the Dutch building industry practice. Here we used three different views on the topic (see Figure 5) in three workshops WS 03, WS 04 and WS 05.

The three views are described in the next paragraph.

First view needed was the limited view from within an engineering / construction company (Brakel & Atmos); the project situation inside is without the variables and influences of the multidisciplinary team in the projects outside. This specific view from the engineers / constructors is used to reflect on the project situation outside. Both individuals as internal teams were used to work traditionally and with the use of MO. The feedback used is that of the needs of knowledge with engineers from architects and visa versa, coupled on improvement of the workshop-setting with architects

Second view needed was inside the project-context with architects and roofers. In both WS 04 and WS 05 we worked with architects from the BNA (Royal Dutch Organization of Architects) and two Dutch Roofer-organizations Het Hellend Dak and Vebidak. Both workshops were divided in two parts; one individual part and one part with team work. In WS 04 the participants used the tools from the start, after an introduction, to determine which of the different design methods could be more effective during the workshop. The two different design methods used are the MO and a within the EURACTIVE ROOFer developed database (D).

In the third workshop (WS 05) we used parallel sessions with teams *with* and *without* using the MO. Here we found the set up where we can compare the different knowledge-types and explicit knowledge used, exchanged and developed by roofers and architects, individual and in teams.

Each final part of the workshops was defined as the evaluation part; the participants / design teams could present and discuss their designs, the collaboration related to the workshop setup and the use of the design method. Through a questionnaire the participants could reflect on the set up of the workshop and the introduced design method (MO). Six month after the workshop was held a second identical questionnaire was sent to the participants to get a better insight in the impact of the workshop and design method into practice. All participants where asked to submit freely to the workshops with the restriction of 5 years of practical experience, all architects are member of the BNA, all roofers are member of the Roofer Organization Het Hellend Dak or Vebidak. The workshops where announced as workshops for Integral Design for Innovative Roofs organized by the BNA and the Roofer Organizations in collaboration with the Technische Universiteit Eindhoven. In the workshops the focus was on working collaborative together on a design task with or without a supportive design method, there was no stress on the research done by the University. The type numbers of the workshops in the text start with WS 03 due to the fact that the first two workshops WS 01 and WS 02 were given with students and not commented in this paper.

2.1 Workshop WS 03

Type of participants		Number	Arrangement
3 disciplines: Architects (9), Roofers (8), Users (8)		25 persons 8 Teams	Two half days, teams and task change working on functions / solutions of integral design
Days hours/day	Sessions/day total	Time/session total	
2 4	3 6	45 min 360 min	
Observations: Master students (during) ADMS-students (after)	Arrangement: 1 per team + video	Using: Predefined interaction form / Output design sessions	Additional: Photos / video / questionnaires after direct + after 6 month

- Aim

Test of the workshop set-up and to distract functionalities and solutions from the design output in the traditional situation (individual and in team) and in the situation with the use of Morphological Overview by the different participants.

- Set up

Workshop In Company (Figure 5.) with professionals of Brakel Atmos, a firm that is specialized in designing and engineering atrium roofs. Three types of professionals were attended; designers, roofers and ‘users. The workshop was done in two days for two different aspects, only the first day was related to Integral Design and the use of MO. The workshop took place on 1 June 2007 in Uden at Brakel Atmos. The day started with an introduction about Integral Design and the design task with a programme of requirements. For all design tasks there was the same time-schedule; 1 hour.

Phase 1 was done individually (a1, o1, g1 etc.), per discipline, with a roof-related design task a. Here we can monitor the explicit knowledge used by the individual participants (a-ig1,a-io1, a-iu1 etc.) to compare with the use in other phases of the workshop. Phase 2 design teams (2.1 – 2.3) with architect, constructor / engineer and user had to work on design task b in the traditional setting without the use of a design method. This situation we can monitor the exchanged and development knowledge within a traditional team (b-id-team 2.1 etc.) setting and compare it with individual disciplines (a-ig1 etc.) and the situation of phase 3; team setting with the use of a design method MO (c-id-team 3.1 etc.). To neutralise the team-building situation the team members are changed (design team 3.1.). The final phase 4 was used to present and discuss the designs (a-ig1 <> b-id-team 2.1 <> c-id-team 3.1 etc.), the collaboration and the experience of using MO.

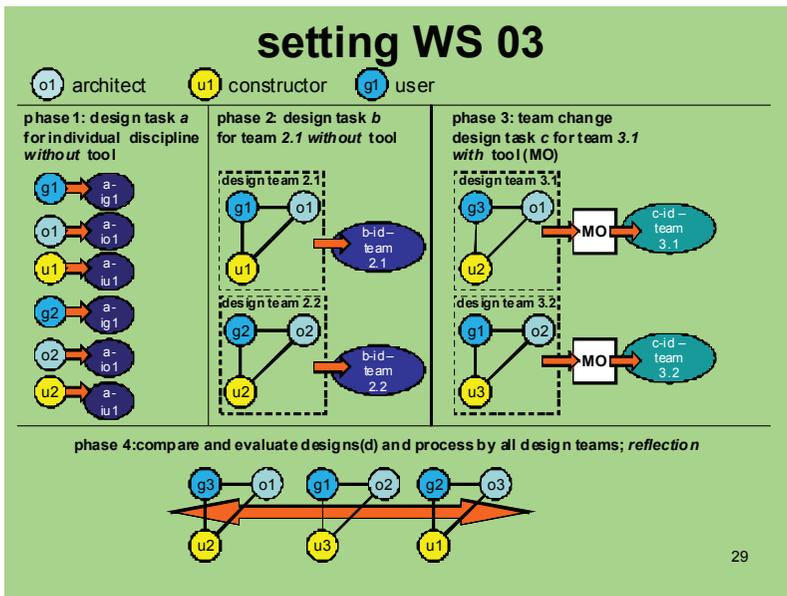


Figure 5: Concept of workshop WS 03; in company; 1 June 2007

- Monitoring

Observation was done by master students, 1 student to monitor each design-team. The observations were done with the help of a predefined interaction observation-list, which included time-schedule and the aspects to look for. The following aspects were reported;

- The items that were introduced,
- By whom the items were introduced.

One assistant-observer monitored the general development, atmosphere and also photographed within regular time intervals the different design-teams and their production of sketches and notes.

- Feed back

Three types of feed-back where generated. The first feedback was generated through the monitoring of the students with the observation lists in combination with the overall observations and photographs of the assistant-observer.

Second feedback was a general evaluation by the group of design-team members after the workshop-session the same day. Third type of feed-back was by answering a written questionnaire directly after the workshop. The same questionnaire was sent by e-mail to the participants after 6 month.

- Results

It appears very difficult to observe the first two experiments in comparison with the other experiments since no structuring methods are given to design teams. One other difficulty is to compare the different design task sessions. Analysis of the results for the solutions of the design tasks needs improvement in criteria and who could do this analysis. For the next workshop comparable design tasks should be developed for the different design settings, as well as observation criteria for these settings. Development of criteria for analysis of design solutions from the different workshop settings and criteria for the analysis-team should be main topic for next workshop.

The workshop and the introduced tool were experienced as very positive for product development and knowledge sharing. This resulted in introduction of the concept to the management .of Brakel Atmos; the concept is now used by the R&D-department of the firm.

2.2 Workshop WS4

Type of participants		Number		Arrangement
3 disciplines: Architects (9) Roofers (8) Facaders (1)		18 persons 9 teams		One day, use of MO and Database (not in paper) in relationship to Integral Design; development of functionalities and solutions
Days hours/day	Sessions/day total	Time/session total		
1 5	4 4	45 min 180 min		
observations: Researcher (during) / ADMS	Arrangement: 1 General + video	Using: Video / Output design sessions	Additional: Photos / questionnaires (direct + after 6 months)	

- Aim

Which kind of functionalities related to the design task do the architects and roofers use; how are they part of the use of the Morphological Overview and design solutions. Is it possible to determine the influence of the use of functionalities and the MO in relationship with the knowledge sharing and knowledge development? Is the set up of the workshop effective for these aims?

- Set up

The workshop was done on 28 September 2007 in Zeist with 18 participants of BNA, Het Hellend Dak en Vebidak. All participants could register free, the only restrictions were that they should have at least 5 years of professional experience and that they were members of one of the named organisations. The workshop WS4 (Figure 6.) was part of the European 6th framework research EURACTIVE ROOFer. Start was an introduction that explained the background of the EURACTIVE ROOFer project and Integral Design. Second part of the workshop was split up in four phases; two phases (phase 1 and 2) with the use of MO and two phases (phase 3 and 4) with the use of the database (D). First part was always done individually, the second part in team with team changing.

For each session the outcomes can be compared with using two different design methods (MO and D), used individually (a-io1 etc <> c-io1 etc.) and in the team setting (b-id-team 2.1 etc. <> b-id-team 4.1 etc.). Phase 5 was a discussion / evaluation on the designs, collaboration and workshop setup related to the use of MO and D. The workshop was completed with the fill in of the standard questionnaire.

- Monitoring and feed-back

There was a general monitoring of the atmosphere during the workshop, done by the two researchers (2 persons) and one assistant. Photos of the work of all participants were made in a regular time-scheme. All the sessions where filmed on video. Postgraduate ADMS-students analysed the sessions afterwards. Feedback from the participants was given through the presentations and evaluation during the workshops and reported by the assistant. All participants filled in the questionnaire directly after the workshop. After 6 month the same questionnaire was sent to all participants.

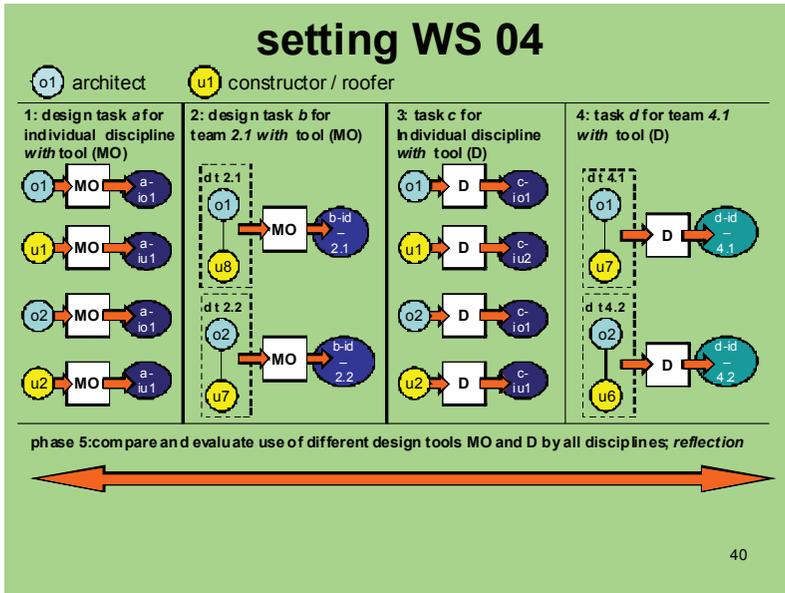


Figure 6. Concept of workshop WS 04; 28 September 2007

- Results

The experiments gave insight in the typology of functionalities used by the different participants, individual and in collaboration. There was a good feedback on experience by the different participants on the use of MO with constructive comment. A comparable setting is still not available. The workshops should also have a major theme as focus; the use of the MO and the Database in the same workshop should be avoided. Development of observation-criteria for the different experiment-settings needs priority. Functionalities as validated and used in the Database should be used as 'checklist' for the analysis of the design results. The participants gave positive response on the workshop and use of the MO.

2.3 Workshop WS5

Type of participants		Number	Arrangement
2 disciplines: Architects (6), Roofers (6),		12 persons 6 teams	One day, use of MO in related to Integral Design; development of functionalities and solutions
Days hours/day	Sessions/day total	Time/session total	
1 5	3 3	90min 1,5h	
Observations: Researcher (during) ADMS-students (during /after)	Arrangement: 1 General / 2 per team 1 per team	Using: Video / MO- overviews / Output design sessions	Additional: Photos / questionnaires (direct after + after 6 months)

- Aim

Which kind of functionalities related to the design task do the architects and roofers use; how are they part of the use of the Morphological Overview and design solutions. Is it possible to determine the influence of the use of functionalities and the MO in relationship with the knowledge sharing and knowledge development? Is the set up of the workshop effective for these aims?

- Set up

Based on the feed-back from the first and second workshops, a different set up was chosen with a parallel setting in order to better compare the differences between the use of functionalities and solutions by architects and roofers, with and without the use of the design method MO (see Figure 7.). The workshop was held at Kropman-office in Utrecht on 17 June 2008. The 12 free attended participants are all members of the BNA, Het Hellend Dak or Vebidak. The workshop WS 05 started with two presentations of professional experts in the roofer building industry; two views on design and engineering innovative roofs.

The first design-task a (phase 1) was done individually without the use of MO (duration 60 minutes); a-io1 etc. and u-io1 etc. as results. After the break the group was randomly split in two groups. One group got a presentation about Sustainable Energy (design team 2.2), the other about the design method Morphological Overviews (design team 2.1). After these presentations they had to work separately in a team setting on the second roof-design task b (phase 2; 60 minutes); design team 2.1. *with* tool MO (b-id-2.1) and design team 2.2. *without* the use of the tool MO (b-id-2.2). The third session (phase 3; 60 minutes) was in reverse with also a change of team. The members of the design teams were changed for the third phase in order to neutralize the team-aspects in time. The third phase team 3.1 did design task c *without* tool MO (c-id-3.1), design team 3.2 did task c *with* the use of MO. Through this cross-over of use of the design method, we have a setting where we can compare the different aspects of knowledge exchange and development and the participants can reflect on the different settings for collaboration and the use of MO. The workshop ended with the presentations of the designs and an evaluation / discussion about the workshop, the design-task and the use of MO.

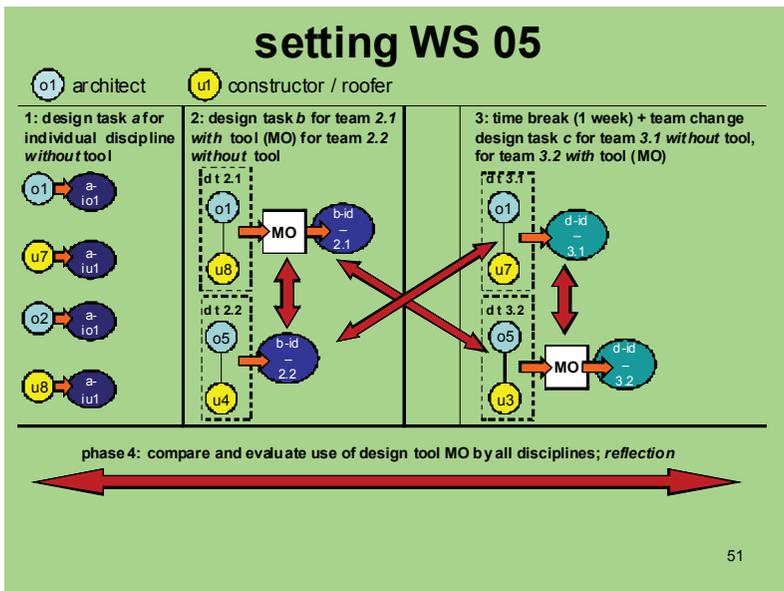


Figure 7 Concept of workshop WS5; 17 June 2008

- Monitoring and feed back

Two post-academic ADMS students and the two researchers did observations. The researchers did a global observation, the students did a closer monitoring with interaction formats and photos of the design work in a regular time-scheme. All the sessions were registered by video. The students made a report of the presentations and the discussion / evaluation. Directly after the workshop all the participants filled in the questionnaire.

- Results

The experiments gave insight in the typology of functionalities used by the architects and roofers, individual as well as in collaboration; with and without the use of MO. The set up of the workshop was far more suitable for comparison. The workshop as well as the use was experienced as very positive, average with a higher rating by roofers. The check of the competence profiles of the participants although should be more strict, it was difficult to get enough participants from the roofer industry with the right competences (e.g. More than 10 years experience and affection with collaborative engineering). The amount of participants is critical related to the risk of participants not attending; a better workshop organisation of the workshop is needed also more separated from the university; this should also be more positive for the scientific value of the results of the experiments. The design task is still too general to point out the specific design and realization knowledge, a more specific design task focused on roof-components, as integral part of the building is necessary.

3 DISCUSSION AND FURTHER STEPS

Although the scientific value of the presented workshops could be discussed, it is more interesting for us as researchers to see the workshops as an adaptable format to learn from in the scientifically setting related to practice. In this way we can discuss the first outcomes as tendencies related to the main aims; the organisation of the workshops, the set-up of the workshops themselves. Finally there should be insight in the characteristics and methods for observation and analysis of the results related to the exchange and development of design- and realization knowledge between architects and roofers.

What can be concluded for the organization of the workshops is that they should be organized by other, professional, organizations than the university. This is necessary both related to two main aspects. The first one is the influence on the participants and the outcomes of the workshop if these are organized by the researchers / university; organization by a professional firm which is already known for given training and lectures to professionals within the building industry give more focus on the needs of the professionals than on research. Other positive aspects for the use of a professional organization are; a better organization of the setting, place of execution, check of amount and competences of the participants and communication through media for professional education. For the set-up of the workshops in 2009 there are three Dutch professional organizations that will be in charge of the organization; the BNA (Royal Dutch Association of Architects), the TVVL (Dutch Society for Building Services) and the BGA-Nederland (Dutch Organization for Training and Education of Building Industry). All the next workshops will be organized in collaboration of these organizations as part of the Dutch Permanent Education of Professionals.

The developed setting of the workshops as shown in Figure 8. gives room to compare functionalities and design solutions with 'zero measurement-situations for individual participants and teams related to the situations with the use of the design method Morphological Overviews. The introduced feedback looping in the third part of the workshop gives the opportunity to all participants to work twice with the MO and to reflect better on the use and effect of it. To organize the workshop in two days, separated one week from each other with the first two design tasks in the first week and the third design task in the second week, the effect of the reflection phase is optimized.

setting WS 2009

steps	designers	constructors	results
design task 1 - functionalities and solutions - individual <i>without tool</i> (MO)	o1 o2 o3 o4	u1 u2 u3 u4	functionalities and solutions Individual <i>without tool</i> registration (analyzing phase)
design task 2 - functionalities and solutions > design - team <i>with or without tool</i> (MO)	o5 o6 o7 o8	u5 u6 u7 u8	Functionalities, solutions + design team <i>with / without tool</i> registration + observation (synthesizing phase)
design task 3 - feed-back > design - team <i>with or without tool</i> (MO) -presentation / evaluation	o1 o2 o3 o4 u7 u6 u5 u8	o5 o6 o7 o8 u3 u2 u1 u4	functionalities and solutions team <i>with / without tool</i> registration + observation + questionnaire (synthesizing phase)

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Figure 8 :concept of workshop start in 2009

First workshops will be organized in March 2009 by the BNA and BGA-Nederland, the second workshops by the TVVL and BNA will be planned in May 2009.

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