Collaborative Design Workshops: Explanation of an Analysing Model for Knowledge Exchange

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Abstract

During the period of 2006-2009 a workshop setting to train Collaborative Design Teams was developed as part of the Dutch Program for Permanent Education for Professionals. This Collaborative Design Workshop has to stimulate members of collaborative design teams, Architects, Roofers and Installers, to share, use and develop collectively specific information of innovative roofs. The aim of the workshop is to support design activities by the use of Integral design method with its design tool Morphological Overviews (MO) to structure information and knowledge exchange between and with commitment of all participants to optimize design solutions.

The paper describes the set up for analysing design team’s explicit knowledge exchange and knowledge development. By using the Design Research Methodology a step by step approach is executed to develop the supportive method. First the development of the analysing approach is described. The second part shows the final procedure; how the data are collected and the different ways to analyse them; the Morphological Analysis and the Functional Sub-solution Video Analysis. First results of the analysiz of the Collaborative Design Workshop are presented and discussed.

Keywords: collaborative design, analyzing model, design tools, morphological overviews
1. Introduction

A lack of innovative designs in the Dutch Building industry can be observed for roofs. A design is defined as a basic scheme or graphic representation that affects and controls function or development for a subject that has to be constructed or manufactured. Innovative designs show smart improvements in design solution by using experiences, and experiments or improvement actions for the design that improves its purpose and functioning greatly. Sub-optimal interaction and cooperation between solutions and construction in design practice of roofs is presented by professional parties as main cause of the lack of innovative roofs (EURACTIVE ROOF-er 2005). During the design process, teams generate new knowledge by exchange and develop information about the design to be produced. Such a design process for the design of a (new) product is called a Collaborative Design (Bento et al. 2004). Within such a setting, actors like Architects and Roofers, differ in cultural backgrounds, their way of working, and have a different motivation of collaboration (Korbijn 1999). Architect and Roofer collaborating on the roof design, acting as representatives of their discipline can be described and defined by their Competence Profiles which is expressed in their design activities as Dorst (1997) explains. Due to interdependency between the participants (Latour 1987) knowledge exchange and sharing is needed by their interpersonal communication and using preferred communication tools (Emmitt et al. 2008).

To identify the various types of knowledge of Architects and Roofers it is necessary to define more specific typologies of knowledge. Van Aken (2005) discriminates object- and realization-knowledge as part of the process-knowledge. This process knowledge through collaboration will link the needed requirements for innovative designs; the object knowledge and the realization knowledge (van Aken 2005). The types of knowledge stated, are communicated between Architect and Roofer (both having another educational background and differ largely in competences and skills) through different kinds of representation (Brereton 1998). Object knowledge can be defined as knowledge on the characteristics and properties of artefacts and their materials. Finally, the third type of knowledge, realization knowledge, can be identified as knowledge on the various physical processes to be used to realize designed artefacts (van Aken 2005). We use only explicit knowledge because this knowledge is notated in a way that it can be administrated and communicated within the team and with other participants, such as advisors and clients, during the process. The design situation of Collaborative Design is described by the set-up of the Collaborative Design Workshop. The design activities as both rational (Simon 1973) and reflective (Schön 1987), for structuring and develop the object- and realization-knowledge, are identified through the use and effects of the Morphological Overviews (Savanovic 2009).

Our research with workshops – learning by doing – for Design Teams in practice with professionals, both for development and evaluation, is ongoing from the year 2000 through the study Integral Design (Quanjel & Zeiler 2003). A new research started by Savanović (2009) in 2004 sets the methodological basis for the knowledge based research in a Collaborative Team-setting. Related to the type of research – technological design – an appropriate methodology is necessary to design the setting as well as the analysing method(s) needed. The main theoretical knowledge used are the Methodical Design model (Van den Kroonenberg and Siers, 1992) and the Design Research
Methodology (Blessing and Chakrabarti 2009). With the help of Design Research Methodology a framework was developed to couple the Design Model of Methodical Design (Zeiler, 1993) and the theory of concepts and knowledge; the CK-theory (Hatchuel and Weil, 2008). This resulted in the ID-method, executed through workshops and the use of a specific support tool – Morphological Overviews (Savanovic 2009) – representing a set of necessary conditions for the creation of integral design concepts for design teams with equal educational background. The Morphological Overviews are used to introduce, discuss and structure the different kinds of knowledge (object- and realization knowledge) of the participants in order to generate more optimal or new design solutions. In this research the focus is on the explicit knowledge exchange between Architects and Roofers / Installers in the setting of Collaborative Design (Collaborative Design Workshops), and the influence of a structuring support tool (Morphological Overviews) on this knowledge exchange.

Parallel to this design a model for collecting and analysing the validated data related to the knowledge exchange and knowledge development had to be evolved. The second paragraph describes the design of the model for collecting and analysing the data from the Collaborative Design Workshops. The third paragraph will focus on the final Collaborative Design Analysing Model. In the last paragraph first results of the executed analysing model will be discussed.

2. Development of a model for analysing collaborative design workshops

As part of the model for Collaborative Design Workshops we had to develop a model with effective and efficient methods to analyse the Collaborative Design Workshops results and the influence of Morphological Overviews as design support tool. This model for analysing methods was developed iteratively mainly based on reflections and redesign practically using the DRM-methodology. DRM consists of four stages: Research Clarification, Descriptive Study I, Prescriptive Study and Descriptive Study II. Several variations of the methodology are possible and necessary to suit the focus and constraints of a particular project (Blessing and Chakrabarti 2009). The four stages of the DRM-methodology could be seen as a problem-solution structure, which is seen as the benchmark of quality of research in many fields. A clear consequence of framing research as motivated by a problem is the need to define criteria for the successful solution of the problem. DRM emphasises the need for formulating success as well as measurable criteria. These criteria need to be defined in the first stage of the DRM research, so that they can be measured against in the fourth and final stage of DRM. This paper focuses on the Descriptive Study II, described in this chapter, and the Prescriptive Study as described in the third chapter.

Research on support tools related to Collaborative Design is in general very much technology driven and less based on a theoretical approach. Most of the research started in 1992 and can be divided in 6 main areas; 3D Virtual Environments, Asynchronous and Synchronous applications, comprehensive systems, community participation and tools (Achten 2009). The research described in this paper focuses on a synchronous application; a tool that supports collaboration by design team members that takes place at the same time. The results – data – are the used representations of explicit object- and realization-knowledge by Architect, Roofer and Installer. There is done much research on analysing
models for design meetings focusing on different aspects of the design (Tang 1990; Cross et al. 1996; Mc Donnel and Lloyd 2009). From 1994 on the Delft-workshop the protocol analysis was the common method. In recent years a wider variety of research methods have been used, drawn from the social sciences and other methods used previously in design thinking research as for instance interaction analysis (Tang 1990), viewpoint methodology (Detienne et al. 2005) or functional linguistics (Mc Donnell 1997). The protocol analysis method generates a lot of data which could actually show us ways of communication related to the explicit knowledge exchange, but only in combination with the explicitly produced data and or video-recordings. As the focus of this research is on representations of explicit knowledge the protocol analysis method is a very time-consuming method for all the workshop-data. Until now we had two pre-workshops with in total about 45 students, four pre-workshops with in total 55 professionals. After these primarily experiments two Collaborative Design Workshops existing out of 4 comparable design tasks were executed with in total 48 professional participants. After the workshops we started with developing a improved model for analyzing the results, which has to add the aspects of ‘used by the participants’ and ‘notated in text or sketch’. That marked the starting point to collect the produced outcomes of the different participants, individual but especially in a Collaborative Design-setting.

To describe the development of the model to analyze the Collaborative Design Workshop we used the DRM-methodology with five criteria which make it useable as a method. These criteria are; aim or outline, steps within the development, evaluation, communication and testing. The aim and outline for each step in the development has to be described before executing this step. The aim should cover each time the criteria which are necessary to function as a method. This defines the next characteristic; the method should have clear steps to be taken to develop and execute. Through evaluation of each step, related to the criteria, the definition of the next step(s) or aim(s) is generated. This makes the method able to test the specific aims in the specific context. Aspects of time; is the organisation of the method time-consuming, and functionality; is the method easy and to use in the correct way, are related to testing the method. Next the development of the three pre-workshops (WS 03, 04, 05) related to the characteristics is described (Quanjel 2008).

The first workshop with professionals (WS 03) was started after two workshops with students with different educational background. Specific methods were used related to communication in search for a suitable method; the Bales-Interaction Process Analyzing Model (Bales 1950, Emmitt & Gorse 2007). The Bales model was tested in these two workshops by three researchers. The analysis of the use of Bales as a method in our research was that the focus of Bales is too much on communication aspects themselves and not on the results or relationships – explicit knowledge – of the communication. Also appeared that the method was difficult to use and very time-consuming related to the data we had from the workshops. Therefore the next step was to modify the analysis-method to a more interaction-design subject-related method and to test it in the WS 03-setting. The setting was In-Company with good circumstances to monitor. We used master-students for assistance to make photographs of the team results each 10 minutes, to prepare the video’s for recording and for monitoring with the Interaction format. The result of this setting was that coding the knowledge flow or knowledge interaction through the use of the Interaction-format was still too difficult to use correctly in real-time and with video-analysis. Second objective was that the results of the analysis was not precise enough related to the use, exchange and development of explicit knowledge by the
team-members. Also the workshop-setting was not good because the steps within this model of WS 03 did not create situations to compare teams using the design method or not.

For the second workshop (WS 04) we decided not to focus on the workshop-setting but only on the definitions of the terms ‘functionalities, aspects and sub-solutions related to the use by the participants and the analysis of the output by the researchers. The workshop-setting was designed to compare predefined functionalities, aspects and sub-solutions from a web-based Database with the developed items within the used Morphological Overviews. Within this setting we succeeded to find definitions which could be used correctly and time-user-friendly within the research-approach and the coupling with the Competence Profiles of the different professionals. These Competence Profiles, delivered by the Professional Vocational-Organisations, describe what should be the knowledge and skills related to a specific function within this profession. Through this Competence Profiles we could identify the object- and realization-knowledge and compare it through analysing the results of the workshops with the ‘real knowledge in practice.

The third workshop (WS 05) we remodelled the workshop-setting from the findings in WS 03 in steps were we could collect the data in different settings. The settings were; individual, in teams (Architect-Roofer and Architect-Installer); with and without the use of MO, with using for each changing team the tool twice to monitor the learning-effect. In combination with the correct setting we worked on the circumstances and technique to monitor with photographs and video-recordings so that they could be used by the post-master students correctly and within the time-schedule.

3. Collaborative Design Analysing Model

The goal of the Collaborative Design Analysing Model is to detect the knowledge exchange and – development between professional Architects, Roofers and Installers in Collaborative Design in the preliminary phase of the design and the influence of the use of the support tool Morphological Overviews. The final product of this model is that the Analysing Model can be used as a method to fulfil this goals in the developed Collaborative Design-Workshop-settings.

First step is to identify what are the knowledge and skills related to object- and realization knowledge connected to the professional Roofer, Installer and Architect. In practice the Vocational Organisations use Competence Profiles to describe these aspects related to a specific function. Through the Competence Profiles we are able to describe the knowledge fields of the different professionals related to functionalities / aspects and sub-solutions. This gives a basis to compare with the results from the design-tasks during the Collaborative Design Workshops. A more practical insight of the real situation is gathered by the use of Case Studies; executed projects which are related to the subject of innovative roofs, roofs with new developments incorporated related to the use of sustainable energy systems. By choosing three pilot projects for the use of Sun-energy in big-scale projects and analyse the preliminary designs on design- and realization aspects – translated in functionalities, sub-solutions and solutions – we get data from a practical situation. These data we can compare with those of the Competence Profiles. Those items which are similar in both steps we can use for comparison with the data from the workshop analysis.
The setting of the Collaborative Design Workshop is designed in such a way that we can subtract comparable data. This is done by introducing three comparable design tasks for three different situations; the individual situation, the team situation without using the Morphological Overviews and the team situation with using the MO for the second time. From the individual situation we can get the profession related functionalities and sub-solutions. By simultaneously take step two, for separate teams working with and without using MO, we avoid a learning effect or influence of these two team-settings. The functionalities and sub-solutions from these two settings we can compare with the individual setting and the third step-setting. In the third step, with changing team-members and executed after one week, one team will work for the second time with MO and the other for the first time. From the results of this steps we can determine if there is a ‘learning effect’ related to the use of MO.

The data collection from each step is the same. All the design-sketches and notations by the participants from all design tasks are collected immediately after the design task is completed. Each participant or team has a code which has to be on all these design-representations. This is checked by post-master students. From all sessions of each team photographs are taken by the students of the design-representations of each coded team, each ten minutes. Finally video-recordings with sound are taken from 3 team-sessions per situation. The tapes are coded by the researcher harmonized with the team-codes. The technical aspects of the video-recordings are done by the students. All data are checked and collected immediately after each design-task and archived in coded maps.

The analysis of the Collaborative Design Workshop data is the next step. These step is first done by the researcher with two different analysing methods; the Morphological Analysis and the Functional Video Analysis. The results of these two methods are the basis of the data-comparison with the results from the Competence Profiles. These methods will be briefly explained. The two different analysis are done separately in time; the first analysis done is the Morphological Analysis. All Analysis are first done by hand and notated by hand before they are digitalized in the different formats.

The Morphological Analysis (figure 1) uses the found functionalities and sub-solutions from all design-representations from each design-situation. All outings are coded and digitalized. By hand each separate design is analysed on type and amount of functionalities and sub-solutions. The found items are marked and coded on the paper-copies. From each design-situation a Morphological Overview is made; all found functionalities (vertical axis) and sub-solutions (horizontal axis) of the members or teams of the same situation are in one MO. Through this method we can compare the different design-situations on amount and type of functionalities and sub-solutions. Theoretically the items from the individual design-situation could be compared on which of those items, belonging to a specific profession, is ‘found in the next team-design-situations.
Figure 1: Example of the Morphological Analysis format (fragment). One format for all found functionalities (vertical axis) and sub-solutions (horizontal axis) of one design-situation. In this example all the items for Installer in the individual design-situation. Delivered amount of functionalities (F), sub-functionalities (SF) and sub-solutions in red below of the overview. The solutions are presented by the coloured lines which connect the used sub-solutions.

The Functional Sub-solution Video Analysis (figure 2) is done separately in time from the Morphological Analysis. Additionally to the MO-Analysis the FSV-Analysis will generate data which will connect the functionalities and sub-solutions to aspects of send, acknowledged and processed. Through coupling these communication aspects with the type of representation and type of knowledge we can get insight into the knowledge flow between the participants. Types of representations are speech, text or drawings and MO. Types of knowledge are related to the CK-theory (Hatchuel & Weil 2009); used only as general functionality or sub-solution not related to the design-task; knowledge re-used and related to the design-task and new knowledge or Concepts. Concepts are an indication of Collaborative Design were the two participants, through the knowledge flow, come together to a ‘creative leap’ where ‘new knowledge is developed needed for the new design solutions needed. The analysing format is split up in time-zones of 2 minutes on a horizontal axis up to 60 minutes.

<table>
<thead>
<tr>
<th>Individual participant</th>
<th>Functionalities / Solutions</th>
<th>Sub-solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installer (1 p)</td>
<td>UWA (1, 2)</td>
<td>Warm water collector / individual (1)</td>
</tr>
<tr>
<td>1. Electrical control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Temperature proof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Light / sun use +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Traffic-space /</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Orientation / sight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Ventilation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Architecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Architecture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Acoustics (11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Fire protection</td>
<td>Emergency routing (11)</td>
<td>Smoke alarm (11)</td>
</tr>
<tr>
<td>16. Utilities</td>
<td></td>
<td>Compartments (11)</td>
</tr>
<tr>
<td>17. Costs (11, 12)</td>
<td>Subsidies (13) SF</td>
<td></td>
</tr>
<tr>
<td>18. Heating + Cooling</td>
<td>Low temp. heating / floor heating (11)</td>
<td>Sun gutter</td>
</tr>
<tr>
<td>19. Sustainable energy use</td>
<td>Domotica system (11)</td>
<td>Sun panels (2)</td>
</tr>
<tr>
<td>20. Sustainable climate use</td>
<td>Floor heating system (12)</td>
<td>Central system (12)</td>
</tr>
<tr>
<td>21. Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Construct / built</td>
<td>Remove asbestos (2)</td>
<td></td>
</tr>
<tr>
<td>23. Comfort / health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Finance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Operational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Users (12)</td>
<td>User profile (12)</td>
<td></td>
</tr>
</tbody>
</table>

| Total                   | 14                          | 1             |

F = 14 SF = 1
Figure 2. Example of the Functional Sub-solutions Video Analysis format (fragment). *One format for all found types of functionalities and sub-solutions colour coded to communication-type (send, acknowledged, processed) and coded related to type of knowledge (functionality, knowledge, concept) and type of representation (talk, sketch, Morphological Overviews). Horizontal axis is the time-schedule with the 2-minutes time-zones up to 60 minutes. Vertical axis shows the knowledge representations. Each block-segment in colour represents one used functionality or sub-solution; the colour represents the communication-type.*
Through experience this time-zone appeared to be functional to monitor. For each participant the types of knowledge and representation is on the vertical axis. For the communication typology a colour-code is introduced representing type of communication related to each time one item (functionality or sub-solution). Through this coding system the type and amount of functionalities and sub-solutions can be determined and compared with the results of the MO-Analysis. Final step is that these results are compared with those of the Competence Profiles and Case Studies, related to type of functionalities and sub-solutions.

For the Competence Profiles is important that the information used is from a classified source and with the latest update; the Competence Profiles are set-up by the Vocational Organisations which are responsible for the correct data. Working with Case Studies the secure selection of the projects related to the participants involved in the process is important. The projects should be state-of-the-art which can be checked through Governmental involvement and participation of crucial parties from knowledge-innovation organisations like for instance ECN, TNO or Syntens.

We selected also on projects which were part of a innovation program for use and development of sustainable energy systems. The data available and the source from which the data can be obtained are connected to the parties involved. Official program-projects have the task and responsibility to archive the data very secure. This can be checked through counter-check the data with other participants in the same program and or literature study. By choosing three comparable projects the tendency can be corrected.

The data-collection of the workshop design-task-results is a strict procedure with a check-list, coding and archive-system for each part. These aspects were prepared by the researcher and executed with help of the post-master students; the researcher has the final check for each item per part. Basis of the data-collection are that the steps in the workshop-setting are done correctly as well as the group-lay-outs for each team (team-change) for each step (design-task). All produced data from the teams is copied and digitalized. The photographs and video-recordings are coded and copied with on two separate back-up hard-disks.

By describing the different steps and evaluation unambiguous with the use of the workshop-script, the check-lists, coding-system and archive-system for the different parts the method is prepared for use by other parties. The rules or guidelines are part of these documents. Necessary for the organisation part are preparation meetings with all participants at least three months in advance because of the planning for location, technique, marketing / public relations and speakers. This is also part of the cooperation with the students. For each new workshop a new class is participating. Their role is important while they assist with the execution-part and data-collecting part. Back-ground information is therefore arranged through in advance lectures about the theory of Integral Design and Morphological Overviews in relationship with the Collaborative Design Workshops as part of their curriculum.

The pre-workshops for development of the model took about one and a half year of preparation and execution. For each Collaborative Design Workshop we start 3 months in advance with the first actions; this is work for 2 people about 1 day a week. The knowledge needed is that of a good office-manager with knowledge about the Building Industry preferably with Architects, Roofers and
Installers. A good office-administration of one of the Professional Organisations is necessary to organise the workshops in time and money.

The analysing of all the data needs the described strict data and basic knowledge about the Integral Design and Morphological Overview theory as well as training with the use of the different analysing methods. The analysing is a time-consuming activity. For one Collaborative Design-Workshop the Morphological Analysis will take about 7 days to analyse. The Functional Sub-solution Video Analysis takes more time because the videos are the full length of each design-team; with 6 video-recordings for each design task. We compare 12 design team-recordings per Collaborative Design-Workshop, first by hand and then digital. The total Functional Sub-solution Video-Analysing part takes about 14 days to execute. Equipment needed is the coded and digitalized video-data, hard copies of the data, paper and a laptop. Overall it takes 3 months for each Collaborative Design Workshop, which means at least 12 months to execute and analyse three sessions with the same model of Collaborative Design-Workshops.

To apply the analysing method correctly needs the background knowledge and training of the use of the methods. Until now the researcher developed and used the methods within the described time-schedule and with correct results. With the first Collaborative Design-Workshop we started a parallel trajectory of an analysing design-task with post-master-students, only for the Morphological Overview-Analysis. We choose only for one method because of the time needed to use the method correct in combination with the available time within their curriculum and the Design Methodology Course. The Morphological Overview-Analysis is also the most important part of the research as well the most interesting in connection with Integral Design and the Methodology Course. This first testing will be executed at the end of 2009, beginning 2010. We intend to do the second test at the beginning of next year and the final testing during spring 2010.

4. Discussion

This research is a reflection on the main questions about design thinking and practice (Cross and Dorst 1996, Mc Donnell and Lloyd 2009). By focussing on a specific field – knowledge exchange and knowledge development of explicit knowledge – and a specific setting – Collaborative Design for professionals in the early design phase – we try to capture the main problem; ‘which data to capture’ (Mc Donnell and Lloyd 2009, p. 3).

Through a step by step approach, within the setting of the developed Collaborative Design Workshop and based on the a grounded theory (Savanović 2009), we explained the Analysing Model for monitoring and analysing collaboration in a practical setting. With the use of data from practice, Competence Profiles, we are able to make a comparison with the ‘existing practical situation’ with the situation needed for future new solutions; data from the Collaborative Design Workshops. Through the use of two developed and different analysing methods, the Morphological Analysis and the Functional Sub-solution Video Analysis, we can capture verified data from this situation. First results show that this Analysing Model can be used as a working method. Two of the three proposed Collaborative Design-Workshops are executed and the third one will be executed and analyzed in
spring 2010. On the basis of the comparison in use of the Analysis Model in the third Collaborative Design Workshop this tendency can be confirmed or neutralized.

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