

MORPHOLOGICAL ANALYSIS OF C-K'S C-CONSTRUCTS ON DESIGN GROUP CREATIVITY

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ABSTRACT

The design of buildings is complex and requires the support of multi-disciplinary design teams. Therefore a supportive design approach has been developed; Integral Design. The Integral design method, with its use of morphological overviews in combination with the C-K theoretical focus on concept generation is an important step to reach true collaborative building design. The approach was tested in workshops with students and professionals and the results indicated a positive effect on the number of generated proposals. With the use of morphological overview in Integral design method and the C-K theory to focus on specific transformations par example from knowledge to concepts or from concepts to knowledge is it possible to make the conceptual design phase more transparent. The innovative Concept-Knowledge theory by Hatchuel and Weil was used in combination with the Integral Design method. This combination enables illustration of different processes within the conceptual design phase of multi-disciplinary building design. It also makes it possible to see the effect of the so called C-constructs to stimulate the generation of concepts. This paper focuses on the effect of the so called C-constructs. Results from earlier research indicated a clear positive quantitative effect in the use of C-construct. However the different effects of C-projects in defining new functions or aspects were not considered; we only looked at the quantitative effect on the number of generated conceptual proposals. By using the morphological overview as a representative of the outcome of the conceptual design process we also looked in more analytical effects of the C-projectors resulting in more functions or aspects mentioned in the morphological overview after implementation of C-projects by design teams.

Keywords: Multi-disciplinary design, morphological overview, integral design, C-K theory

1 INTRODUCTION

Achieving higher comfort for occupants with net-zero energy is one of the many challenging demands of the built environment. There is the need for innovation through collaborations in which ideas from one domain, discipline or functional area are imported into another [1]. This essentially leads to cross disciplinary boundaries intervention that stimulates the occurrence of boundary spanning. In the master project Integral Design students from different disciplines (architecture, structural engineers, building physics, building technology and building services) have to design a complex zero energy building. The students use supportive tools and methods to help them to solve the immense difficult design task, see [2] for more information about the design educational context.

Performing group creativity sessions which combines individual knowledge for creating better proposals is one way of achieving cross-disciplinary boundaries [3]. For this we chose a popular Dutch design method to develop an integral design method to be used in a multi-disciplinary building design setting. The main aim of our integral design approach is to support design teams. Supporting design teams could improve conceptual design collaboration in order to stimulate creation of new design proposals. . As such we analysed the effect of applying design theory and design tools to increase creativity within multi-disciplinary design teams. In analogy with Le Masson et al. [4] we looked at influencing the interplay between creativity issues and design theory. The main research question is the effect of one specific intervention; the introduction of C (Concept)-projectors from the Concept-Knowledge (C-K) theory of Hatchuel and Weil [5], on the integral design method in order to stimulate the creativity of design teams. In section 2, details of the research methodology are presented and in section 3, a description of the experiments with workshops for master students, especially the introduction of C-projectors are presented By applying C- projectors derived from the C-K theory it

was possible to stimulate the transformations from knowledge to concepts leading to further expansion of the solution space. Section 4 presents the results from the use of C-projectors within the workshops. In section 5 there is a discussion about the addition to the integral design approach and its results, followed by conclusions in section 6 about the added value of the intervention to support creativity within the integral design approach.

2 METHODOLOGY: INTEGRAL DESIGN AND C-K THEORY

In the earlier 1960s design methods, developed to support designers [6], were based on the application of 'scientific' methods derived from operational research methods and management decision-making techniques from the 1950s [7]. Although systematic prescriptive approaches were helpful, they were hard to apply in design, which is considered to be a largely ill-structured activity [8]. Up to date, there has been no clear picture about the most effective way to support designers. Classical design methodology has deficits in supporting designers and needs a substantial reformation [9]. This resulted in many different models of design [10 - 14]. In the Netherlands a specific design method was developed by Van den Kroonenberg [15], which had exceptional characteristics [16]. In the Netherlands methodical design is the most popular design method in the mechanical construction industry. Therefore we used the methodical design method and transformed it into a method more suited for multidisciplinary building design: integral design [17]. A distinguishing feature of Integral Design is the intensive use of morphological charts to support multi-disciplinary design activities in the design process. A morphological chart is formed by decomposing the main goals of the design task, derived from the program of requirements, into functions and aspects, which are listed on the first vertical column of the chart. After this step the related generated proposals are listed on corresponding rows. The morphological charts, made by each individual designer, can be combined into a design team's morphological overview [18].

One other adjustments to the design method was to combine the Integral Design approach with C(Concepts)-K(Knowledge) theory, which enables us to focus on the distinction between redesign (K-K transformation) and integral design concept generation through C-K transformations [19]. Normally in traditional design the focus is on K-K relations. In addition, C-K theory offers specific value in the conceptual building design stage, where it can be used to focus on K-C, C-C and C-K transformations. In the next stage of development the use of the so called C-constructs of the KCP-method was investigated to stimulate the creation of new concepts in the Integral Design workshops [5, 20]. The intended effect of the C-projectors is the expansion of the solution space in C, after which, by means of research and evaluation, is the expansion of space K, via the transformation of C-K. Applying C-projectors to the Integral Design approach enables an expansion of the knowledge domain formed by the design task related morphological overview, and by stimulation of new transformation between space C and space K. These C-constructs are domain strange concepts, which can be used as a source of inspiration and the start of further research to make a connection with existing domain knowledge in space K, and after evaluation determine the possibility of proposals resulting from these new connections.

3 EXPERIMENT

To test the effect of the intervention of using C-projectors in a student's conceptual design session, workshops were used within the master project integral design (MIO) of 2012. In this multidisciplinary master project students from the faculty of the Built Environment (architects, structural engineers, building physics, building services and building technology) students were tasked with building a net zero energy building (nZEB). The workshop started with two afternoon sessions followed by two morning sessions. The focus of the workshops was to teach the students the basic ideas about Integral Design and the use of morphological charts and morphological overviews. In all design settings the teams were given the same or similar design tasks as used in the Integral design research by Savanovic [17]. At the end of the first part of each session the teams developed a morphological overview from the morphological charts. The individual parts of the sessions 1, 2 and 3 took 20 minutes and the team parts lasted 40 minutes. For the first individual part of the sessions, in developing the morphological charts, communication between participants was discouraged and for the third session, an experienced professional joined the student design team. At the end of the third session, a lecture was given about C-K theory and the possible application of C- projectors thereafter

the design teams tried to generate concepts with the help of some examples of C-projectors that were given to them. The number of functions and proposals mentioned by the designers in their morphological overviews makes it possible to compare the outcomes for all different team's configurations and different workshop sessions. From the used forms we counted the number of functions and proposals in the morphological overview as well as the additional functions and proposals mentioned after the introduction of the C-projectors. The focus of the new assignment was on the application of C-projectors in making the step from existing knowledge to concepts stimulating K-C transformations. 20 students participated in session 3 as well as 6 professionals, one in each student team.

4 RESULTS WORKSHOPS INTEGRAL DESIGN

Here we present only the results from the third session as we essentially focussed on the effects of the application of C-projectors. The results from two different teams are presented in Fig. 1. On left side is the original morphological overview and on the right side the additions after the application of the C-projectors placed in a separate morphological overview. From Fig. 1 it clearly shows that there is a difference in the increase of mentioned functions as well as a difference between the numbers of notated proposals.



Figure 1. Two examples of the morphological overview and the use of C-projectors. Left the original morphological overview and right the additions to it through the application of the C-projectors

The use of the morphological overview based on the individual morphological charts of each individual designers led to an increase in the number of mentioned functions from 7.7 to 9.5 an increase of 23% as well as an increase of average notated proposals from 26.5 to 36.3 an increase of 37%. Applying the C-projectors led to a further increase in the number of mentioned functions from 9.5 to 10.8 (14%) and an increase in the number of mentioned proposals from 36.3 to 48.5 (34%). The use of the morphological overview makes it possible, for each design team, to look in detail at the mentioned functions/aspects as well as the average number of mentioned proposals

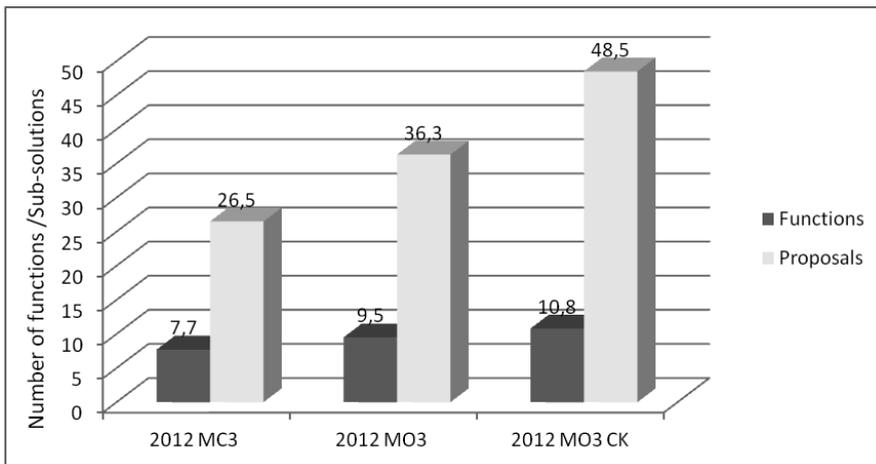


Figure 2. Average combined results of session 3 of the 2012 MIO workshops

Besides looking at the total number of proposals and functions we were interested in the effects of the C-projectors in the different design teams. From Fig. 3 these effects can be concluded: in all teams the number of generated proposals increased from 7% up to 141 %, see Fig. 4. The effect to the increase in the number of notated functions is much smaller: between 0 to 100 % with an average of 19%.

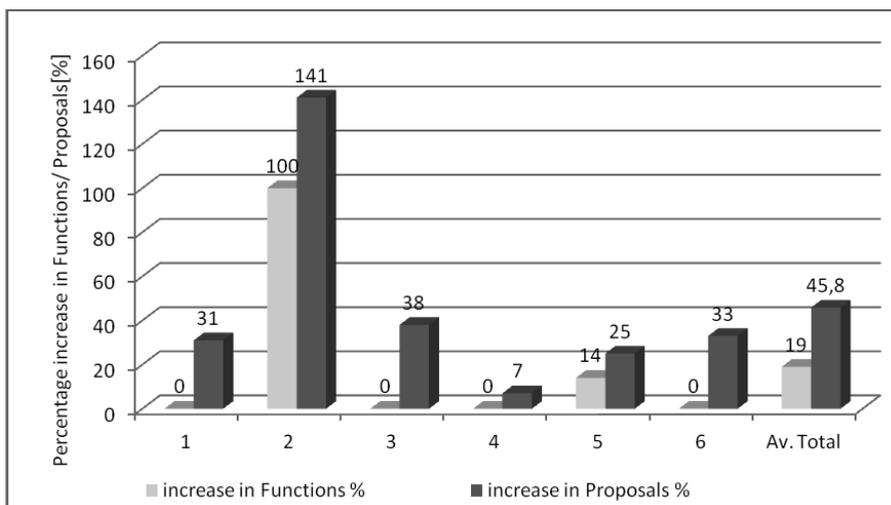


Figure 3. The relative effect of C-projectors on the number of functions or proposals in %

5 DISCUSSION

The spread within the results of the individual design teams is quite wide, which might be due to the limited number of design teams (six) in each design session. The difference between the outcome of design teams, depended on the synergy between the participants, as well as on the individual talent, social capabilities and experience of the participants.

When we compare the results of 2012 with those of the 2011 workshop series the results were slightly less positive; the morphological overview of session 3 of 2011 led to a significant increase in additional mentioned functions up to 61.5% [from 7.8 to 12.6] compared to 17% in 2012, as well as an increase in proposed proposals up to 42.3% in 2011 [from 30 to 42.7] compared to 33.6% in 2012.

As can be seen in Fig. 3 the results are highly influenced by the results of team 2 where the effect of the application of the C-projectors lead to an enormous increase of mentioned functions as well as

proposals. This was mainly caused by the relative small amounts of functions and proposals mentioned by this team, as can be seen in Fig. 4. So clearly it can make a huge difference how you present the results as relative results in a percentage or as absolute results in the real amount of results.

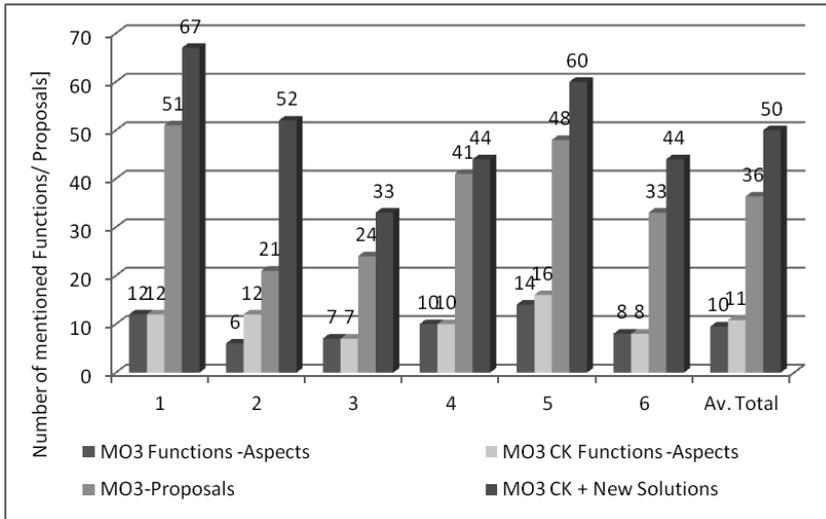


Figure 4. The absolute effect of C-projectors on the number of notated functions and proposals by each design team

This proves that we have to be very careful about drawing conclusions based on a limited amount of experiments and participants. Never the less in all situations there was a positive effect of the application of the C-projects. However, to be sure about the effect, we should in future also do the experiment in a kind of double blind procedure. So for example let 3 teams work with the C-projectors and give the other teams the same time to work on the extension of the morphological overview without any new input or tools.

The results of individual design teams can show large differences, depending on all kinds of aspects related to personality, social capabilities, attitude etc. of the individuals within the teams. Therefore we selected students from our University who all had similar educational background and experience, as well as were about the same age. Nonetheless there is still a big difference in the manner people are able to express, discuss and share their thoughts in design sessions.

As the proposals are put forward in the conceptual design phase there is no possibility to make statement about the quality of the mentioned proposals. Therefore we only included quantitative results in relation to the effect of the interventions that we made to the design process. The only thing about quality might be that the more functions are mentioned the broader the analysis of the design brief might be done, in that case there is clearly a positive effect of the application of the C-projectors, as there was an increase in the average number of mentioned functions.

As stated by Le Masson et al. [21] there is an interplay that links creativity and design theory. That interplay leads to new ways of managing design, new ways of managing knowledge, processes and organizations for design activities. In our case we used the framework of integral design in combination with C-K theory to stimulate creativity within multi disciplinary building design teams.

6 CONCLUSION

Integral design method enables the merger of different perspectives of all designers and consulting engineers, involved in the design process. In the conceptual phase of integral design, morphological overview represents the design team's interpretation of the design task and the related design knowledge and as such it defines the problem and solution space of the design task. The integral design method is based on experimental workshops for professionals and was now used to teaching multi disciplinary building design to students in workshops for their master project. We researched how for student design teams, interventions to the integral design method could improve the

quantitative outcome of the design process. Two interventions were tested to stimulate the creativity of design teams within the integral design process; here we focused only on the application of C-projectors by the student teams which were enforced by a professional. The C-projector's intervention had a significant positive effect on the increased number of generated proposals and as such had a stimulating effect on the creativity of the student design teams within the integral design process.

ACKNOWLEDGEMENT

This research was done in cooperation with the engineering consulting companies: Nieman, Smits van Burgst, Valstar Simonis, Deerns and RHDHV. The foundation WOI, OTIB, SBR and PIT as well as the professional organisation UNETO-VNI financially supported this research.

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