Do Handstorm Principles Support Creative BIM Collaboration?

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Abstract –

Building Information Modelling (BIM) and Internet-based tools are communication aids. During the product and process design phase partners must coordinate, cooperate and collaborate with stakeholders. Creative and collaborative work is necessary in order to create value for the end consumer and society and to develop smart buildings. For this type of work design managers must have collective skills, expertise, understanding and knowledge. Furthermore, there must be an atmosphere of openness, honesty, trust and mutual respect. Merely using the current BIM tools may not be enough for future creative and collaborative work.

To enhance creative and collaborative work, the Handstorm principles have been developed based on a literature review and empirical research on collaborative design. The Handstorm principles are interventions that encourage professionals to be creative, to work collaboratively, and to support each other during design meetings. To help professionals learn and practice these skills, a *creativity facilitation* course has been developed, tested and validated.

The research question in this paper has been formulated as follows: *Do the Handstorm principles support creative BIM collaboration?* During the first phases of BIM, the collaboration can be effectively realized by using models and internet-based tools. However, subsequent phases must involve more of the knowledge and experiences of the stakeholders. To encourage this involvement, design managers must have specific skills to plan, organize and lead creative processes. These skills can be learned in a creativity facilitation course based on the Handstorm principles.

Keywords –

Social BIM, collaboration, creative thinking, design meetings, design principles

1 Introduction

In this paper the results of the PhD study *Handstorm Principles for Creative and Collaborative Working* [1] have been used to determine whether these principles support creative BIM collaboration. In this paragraph we will first discuss the field problem of the PhD study and the solution approach. Subsequently, the limitations of BIM and the research question will be addressed and then the structure of the paper will be described.

1.1 Field problem and solution approach

A field problem is a problem that occurs frequently in practice and for which there is still insufficient generic knowledge to solve it [2]. At the moment, professionals, stakeholders, clients and users in the Architectural Engineering Construction (AEC) sector make too little use of each other's knowledge, skills and experience during design meetings. This poor collaboration is evident in the way in which building joints are sometimes engineered in practice. It is important for designers to ask questions that can help determine whether the following issues have been sufficiently addressed: preventing thermal bridging, labour-friendly delivery, positioning and fixing of building components on the building site, and environmentally friendly ways of dismantling building components [3]. The conclusion reached during a seminar that was organized by the Universitair Centrum voor Bouwproductie (UCB) was that intensive collaboration between various professionals is needed when designing joints in a changeable and sustainable building [4]. In his PhD research, Olie [5] characterized this problem of collaboratively designing building joints as follows: "Good joints in buildings depend on good connections between parties."

For the PhD study, the field problem has been described as follows: *Creative and collaborative working during face-to-face design meetings in the AEC sector is not planned, organized or conducted with adequate knowledge and skills.* The word "meetings" in this

problem description can be defined as a "process undertaken by two or more interested individuals, sharing their collective skills, expertise, understanding and knowledge (information) in an atmosphere of openness, honesty, trust, and mutual respect, to jointly deliver the best solution that meets their common goal" [6]. The aim of a design meeting can be any of the following: (i) assessing the situation, (ii) exploring the vision, (iii) formulating the challenge, (iv) exploring ideas, (v) formulating solutions, (vi) exploring acceptance and (vii) formulating a plan [7]. Meetings in the AEC sector are primarily conducted in a face-to-face setting. Rhoades and O'Connor stated that "in face-to-face groups the affect, or emotion, experienced by group members has an impact on the group's cohesiveness" [8]; this factor has implications for group performance, which is not the case with computer-mediated groups.

One approach to solving the field problem is to augment the knowledge and skills of the professionals by having them take part in a creativity facilitation course. The main aim of the creativity facilitation course is *to teach professionals to better plan, organize, and conduct face-to-face design meetings in the AEC sector*. The following aspects of successful creativity facilitation are listed below.

(i) Oriented to the AEC sector

The participants of (design) meetings in the AEC sector generally originate from very diverse professional groups. These professionals often have their own language, tools, codes, unwritten rules, and scientific paradigms. Facilitating a creative meeting that effectively makes use of this diversity requires a specific approach to make the participants responsible for the wishes of the client, and to help them let go of their personal solutions. By definition, participants of a meeting do not form a team; if a participant is unable to attend, he/she may send a replacement without announcing this in advance.

(ii) Involved facilitation

In most meetings, the project leader guides the meetings by focusing on his/her own issues, and insufficiently considers the contributions of the participants. In order to avoid this lack of participation, a leader should have an enterprising spirit and a proactive attitude which can contribute to an atmosphere of involved facilitation.

(iii) Stimulating cooperative learning

The professionals participating in design meetings are very experienced in their own disciplines. Collaborative working means that aspects of each discipline contribute to a final concept or idea. To realize this synergy, the facilitator must stimulate the participants' empathy and eagerness to learn

(iv) Using varied skills and intelligences

Professionals come from diverse disciplines, and have their own specific skills and intelligences. To help them work together, the facilitator should make use of all of their skills and intelligences by incorporating effective working methods that can be characterized by the values of playfulness, imagination and inventiveness.

(v) Creating an open culture

Participants of a meeting often have their own agenda to optimize their interests. There is a lack of transparency regarding these agendas, minimal respect for other participants' professionalism, and poor exchange of knowledge and experiences.

(vi) Consulting a set of design principles

Planning, organizing and conducting design meetings is not part of the (design) process manager's or project manager's daily work. He/she is engaged in construction engineering and management processes and not in running group creativity processes. Therefore, these managers must learn how to use scientific prescriptive statements, which in this study is a set of design principles. A safe environment, such as a course can be very helpful in this regard.

The knowledge and skills required to plan, organize, and conduct face-to-face design meetings can be taught with a course that has been developed using a suitable set of prescriptive statements or design principles.

1.2 Limitations of BIM

Building Information Modelling (BIM) and Internet-based tools are aids for automated workflows. These 'hardware' aids have an impact on the interactions during product and production design of building objects. Some impacts have been described in the literature and are identified hereunder.

In the study *BIM-based collaboration design and socio-technical analyses of green building*, El-Diraby, Krijnen and Papagelis [9] "noticed a few limitations/opportunities in the way current BIM tools address the needs for integrated design, collaboration and analysis", namely communication and interactions did not use BIM tools and end users were not engaged.

The bibliometric-qualitative literature review *Collaboration in BIM-based construction networks* (BbCNs) [10] aims to analyse the scholarship on collaboration on BbCNs. Two factors that need to be investigated are team members' knowledge, skills and abilities and the match between different members in BbCNs.

By developing and prototype validating a dedicated collaboration platform for Integrated Project Delivery (IPD) [11] to improve efficiency and reduce waste AEC projects, the researchers came to the conclusion that "offline meetings are still needed when complex and important problems are discussed".

1.3 Research question

Design managers need specific knowledge and skills to enhance creative BIM collaboration. These skills can be learned by following a course on planning, organizing, and conducting face-to-face design meetings. Therefore, the research question in this paper is formulated as follows: *Do the Handstorm principles support creative BIM collaboration?*

In the following paragraph a summary will be given of the PhD study *Handstorm principles for creative collaborative working* [1] and in paragraph three the developments of BIM collaboration will be explored. Paragraph four will provide an answer to the research question.

2 Handstorm principles

In this paragraph the above-mentioned PhD study will be described, focussing on the following aspects: (i) research design, (ii) the necessary conditions for successful automated collaboration in construction, (iii) developing a design principles-based creativity facilitation course, (iv) validating the set of design principles, and (v) conclusions, reflection and discussion.

2.1 Research design

The research set-up is design based and scientific. Research activities were formulated using the *research-design-development cycle*, which is a framework that describes knowledge flows and experience flows between praxis and science [12].

The central research topic, *developing a creativity facilitation course based on validated design principles,* has been broken down into three main research topics:

- Finding parameters to describe collaborative working in design meetings
- Developing the creativity facilitation course based on design principles
- Validating the set of design principles

When carrying out the research on these topics, the following research strategies were used: desk research, case study, experiment, and survey research.

This *design scientific research* aimed to achieve maximum practical relevance and maximum methodological thoroughness. The latter was achieved by developing the design principles on the basis of existing scientific knowledge and by validating them through practical implementation and evaluation. The requirement of maximum methodological thoroughness was also met by assessing the validity of the evaluation and qualification results by applying the rival explanations method. The requirement of practical relevance was met by implementing the course, which is based on a set of design principles, in practice. A beta test was carried out by publishing some of the design principles and evaluation questions at an early stage and inviting fellow academics to experiment with and report on them. The methodological thoroughness requirement was also met by the triangulation of this data – the use of different samples, spaces and persons.

2.2 The conditions for collaboration

For the first main research topic, *finding parameters to describe collaborative working in design meetings,* desk research and a case study were carried out. The desk research yielded a research perspective from which to consider collaborative working. The case study consisted of the analysis of 37 meetings held during the design and production phases of a prototype for an industrial, flexible and demountable construction system. The parameters found – ‘aim of meeting’, ‘control of meeting’, ‘participants’, ‘tools’ and ‘outcomes’ – were linked to the basic elements of the Structured Analysis and Design Technique (SADT). This resulted in a system model that can be used to describe and design meetings. An article on the implementation of this main research topic was published by Van Gassel, et al. [13].

2.3 Developing creativity facilitation course

The second main research topic, developing the creativity facilitation course based on design principles, has been broken down into four sub-topics:

1. Finding mechanisms that enhance collaborative working in a literature review of PhD studies.
2. Finding successful interventions based on the practical experience of the researcher.
3. Developing the design principles by synthesizing the mechanisms and the successful interventions.
4. Developing the creativity facilitation course based on design principles.

The research consisted of desk research and experiments. Sub-topics 1, 2 and 3 yielded 15 design principles; the syntax for each was classified on the basis of Context Intervention Mechanism Output (CIMO) logic. These design principles are described briefly below.

The set consists of 15 design principles, which can be summarized as follows: (i) plan a detailed meeting scenario, (ii) invite a variety of participants, (iii) explain work methods simply, (iv) have participants listen to each other, (v) put reluctant participants to work, (vi) create rhythm in the group’s activities, (vii) reformulate the definition of the problem, (viii) don’t be afraid to deviate from the meeting plan, (ix) continually change the circumstances, (x) take participants out of their comfort zones, (xi) let the participants do the work, (xii) let the hands do the thinking, (xiii) alternate between

strict and lenient, (xiv) close the meeting with perspective, and (xv) choose the work method most appropriate for the meeting. To plan and conduct these meetings, design managers need knowledge of creative and collaborative work and creative (leadership) behaviour.

The final sub-topic yielded a course program and an enrolment leaflet. This leaflet sums up the aims of the course: oriented to the AEC sector, about involved facilitation, about stimulating cooperative learning, about using varied skills and intelligences, about creating an open culture, and about consulting a set of design principles.

The design principles and development process have been reflected upon. The design principles cover the meeting parameters 'control of meeting', 'participants' and 'tools' equally for each design principle. Background information was provided for each design principle and it was demonstrated that design principles strengthen the sub-aims of the course. The development process has yielded a method that synthesizes scientific knowledge and practical results into new design principles.

2.4 Validating the set of design principles

The third main research topic, validating the set of design principles, was broken down into three sub-topics:

- Evaluating the creativity facilitation course in practice;
- Qualifying the implementation of the set of design principles;
- Assessing the validity of the evaluation and qualification results.

The course was evaluated after it had been delivered six times. A questionnaire was used to measure learning results and participant satisfaction. This measurement showed that the course scored well regarding 'knowledge of joint creative thinking' and it was scored very highly regarding 'improvement of creative behaviour' and 'improvement of creative leadership behaviour'. Course participants were very satisfied and after the course exercised the skills they had learned in practice.

The qualifying of the implementation of the set of design principles involves considering the measurement results of the learning outcomes and demonstrating the coherence between the three learning outcomes 'knowledge of creative and collaborative thinking', 'creative behaviour' and 'creative leadership behaviour', and the set of design principles. The coherence between the descriptions of the learning outcomes and survey questions can be qualified as fair based on the 5-point Likert scale (i.e. poor, fair, average, good and excellent).

The beta test was carried out at the Federal University of Juiz de Fora in Brazil, as part of a bachelor course based on the use of design principles. The answers given to the evaluation questions show that students were satisfied with the course (on a scale of one to five with a mean score of 3.75 (standard deviation 1.28 and N = 8)). Although there was initially some resistance among the students, it disappeared during the test. The coaches found that the results obtained when applying the design principles were better in comparison with situations in which the design principles were not used. It would seem reasonable to conclude that the use of the design principles is useful. The beta test was described by Pinheiro and Queiroz [14].

2.5 Conclusions, reflection and discussion

The central research topic, *developing a creativity facilitation course based on validated design principles,* results in an attractive and broadly applicable solution to the mentioned field problem, and fulfils some needs of 'structuring face-to-face meetings' and 'guidelines for trained facilitators to enhance group creativity' from the academic domains of *building design management* and *small group creativity*.

The creativity facilitation course is *applicable* for the professionals working for companies that are involved in performance-oriented tenders in the AEC sector and the course now forms part of the education program at the BAM Business School. The research has also yielded a set of Context Intervention Mechanism Output (CIMO) structured design principles that can be used as a guide when planning, organizing and conducting all kinds of design meetings. The principles can also be used to develop creativity techniques, such as two simulation games ('Partner selection' and 'Creative supply and demand') and two creativity techniques ('Constructing a platform' and 'Constructing metaphoric objects'). The practical use of the design principles is publicized under the brand name Handstorm® on the www.handstorm.nl website.

The research further yields the following tools and findings for the domain of *design science research*: (i) a system model that can be used to devise and describe meetings, (ii) a procedure that has been devised to develop design principles by synthesizing successful interventions and mechanisms, (iii) a questionnaire in which participants evaluate the course, (iv) the *research-design-development cycle* has proven to be very suitable for designing the research, and (v) a procedure for the assessment of the validity of the evaluation results attained on the basis of the plausible rival explanations method.

To enhance the *reliability* of the results, the researcher has implemented the course six times in practice, used existing knowledge, initiated a beta test, and evaluated the course on the 'indicative' level.

The *validity* of the set of design principles has been assessed by qualifying the evaluation results and the

results of the beta test. To estimate the validity of the set of design principles, the plausible rival explanations method has been used. The beta test that was carried out at a university in Brazil shows that design principles are useful when devising, organizing and planning education-related meetings.

Regarding the *generalizability* of the design principles, these principles are described as a robust basis for attractive and broad applications for creative and collaborative working.

The research has a number of *limitations* and thus suggestions are proposed for *future research*. Only the *indicative* evaluation level was chosen for the course because the course had been implemented only once in practice. In future research the higher evaluation level *causal* should be chosen, as now more are data available regarding the impact of the interventions on the outcomes.

The experiences of course participants were measured with a survey. The learning outcomes were only measured at the end of the six courses. In this study, the participants were asked to rate how much they had learned during the course. This form of self-assessment is less objective than taking measurements before and after training. In future research, it might be better to measure the knowledge and behaviour of participants at the beginning and at the end of each course.

The usefulness of the set of design principles was determined by measuring the coherence between the text of the questionnaire and the keywords of the 15 design principles. This coherence can be considered *fair* but there are clearly differences between the learning outcomes 'creative behaviour' and 'creative leadership' in relation to the design principles. Further research can more explicitly test the course participants' knowledge about the set of design principles as a part of the evaluation and can thereby enhance the coherence.

The Structured Analysis Design Technique (SADT) system model for meetings is based on just one case study, but it has on numerous occasions been used to analyse and describe various construction processes during the Master's degree program in Construction Management and Engineering at the Eindhoven University of Technology. It is recommended that further research be carried out on the validity of the SADT system model for meetings (e.g., in the form of additional case studies).

Other worthwhile research would involve testing the effectiveness of the Handstorm principles during every phase of creative and interdisciplinary collaboration processes, for example in the ICT, government and health care sectors. In addition, it would be advisable to establish whether the principles are applicable outside a Dutch or Brazilian context.

3 Developments BIM collaboration

Answering the research question in this paper, *Do the Handstorm principles – as learned in a creativity facilitation course – support creative BIM collaboration?* requires insight into the developments in BIM collaboration and the competences desired by design managers to enhance this collaboration. The findings of several authors regarding theses aspects are summarized hereunder

Grilo and Jardim-Goncalves [15] distinguish five interaction types along the x-axis: communication, coordination, cooperation, collaboration and channel. Each type of interaction has three value levels along the y-axis: efficiency, differentiation, and value innovation. Collaboration is related to value innovation and described as 3D BIM & Collaborative working environment. During the design of the product and production processes for the built environment, partners must coordinate, cooperate and collaborate. Creative and collaborative work is necessary in order to create value for the end consumer and society and to develop smart buildings.

Uhm, Lee and Jeon [16] have analysed BIM jobs and their required competences. The BIM jobs were classified into eight BIM job types: BIM project manager, director, BIM manager, BIM coordinator, BIM designer, senior architect, BIM mechanical, electrical and plumbing coordinator, and BIM technician. According to their study, the BIM project manager did not require a number of *common* competences in relation to creative collaboration. Some relevant competences include the following: "work styles of cooperation", "design knowledge", "work activity of thinking creatively", "work activity of commutating with supervisors and peers", and "work activity of providing consultation and advice". This study may contribute as a guide to developing a training program for BIM design managers.

In the study *Enhancing collaboration in BIM-based Construction Networks (BbCNs),* the authors Mignone, Hosseini, Chileshe and Arashpour found four main approaches for enhancing BIM collaboration in the literature. The second approach "suggested the incorporation of the principles of effective team working in tertiary education programmes" and the third "contended that members of BbCNs should be regarded as constant learners to foster collaboration" [17].

Future generations of BIM systems need real-time co-creation capabilities during the development phase. It is the people who collaborate and not the systems. Therefore, the future systems, which are known as Social BIM, focus "on the *procedural aspects of BIM* by encapsulating the metacognitive, behavioural, interpersonal and confidence skills that shape effectiveness of collaboration". This statement comes

from the study *Social BIM: Co-creation with shared situational awareness* [18].

Based on the findings of these authors, it is clear that enhancing creative BIM collaboration requires collective skills, expertise, understanding and knowledge by design managers in an atmosphere of openness, honesty, trust and mutual respect.

4 Do the Handstorm principles support creative BIM collaboration?

The research question in this paper has been formulated as follows: *Do the Handstorm principles support creative BIM collaboration?* During the first phases of BIM, the collaboration can be effectively realized by using models and Internet-based tools. However, subsequent phases must involve more of the knowledge and experiences of the stakeholders. To encourage this involvement, design managers must have specific skills to plan, organize and lead creative processes. These skills can be learned in a creativity facilitation course based on the Handstorm principles.

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