Handstorm principles for creative and collaborative working

Frans van Gassel

/ Department of the Built Environment

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for creative and collaborative working

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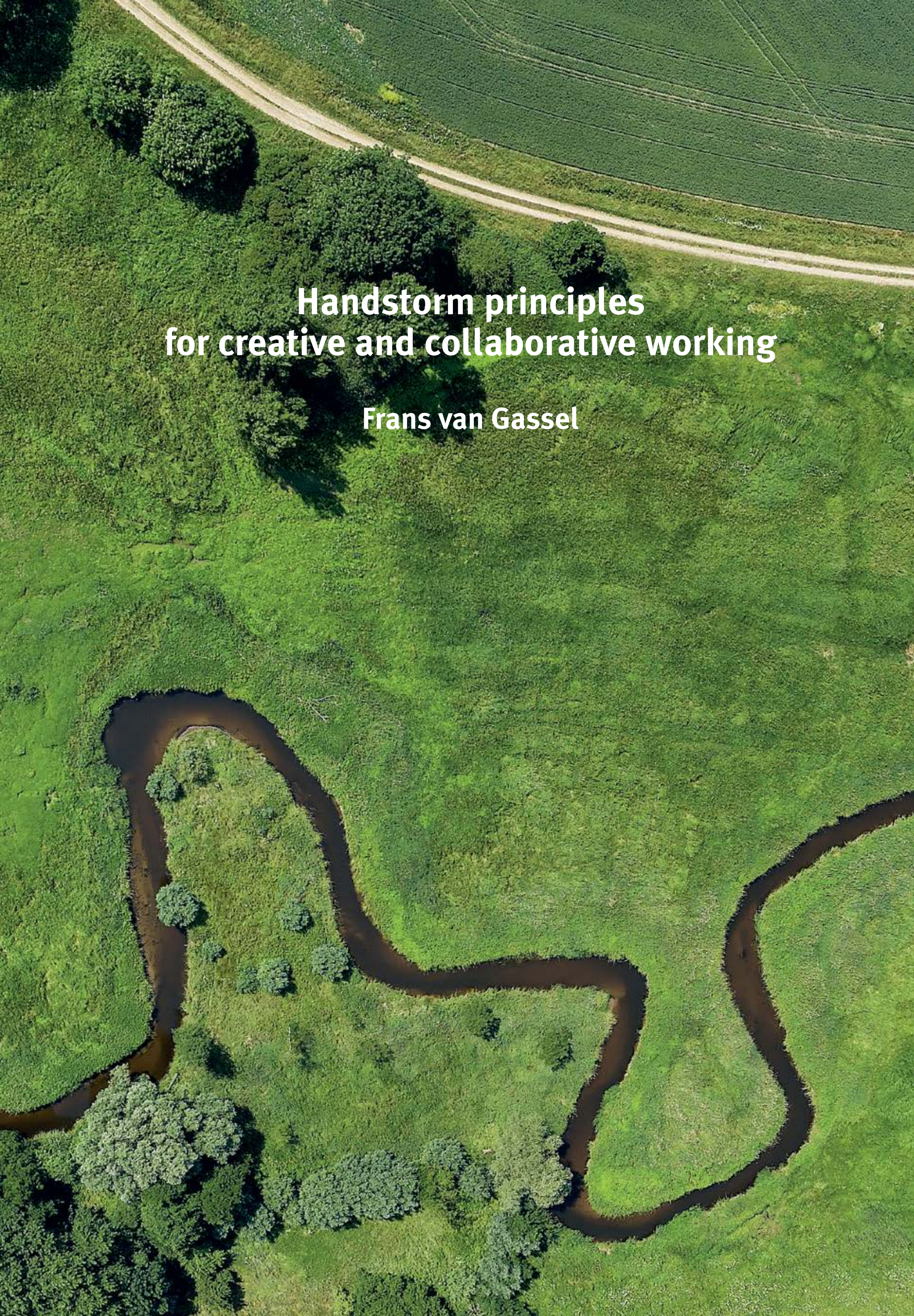

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Voor Marjan, zij bewandelde met mij het pad van ontdekkingen...

In the early phase of my Ph.D. research, I could only paint my research theme and define it with the words: dreaming, thinking, feeling and doing.

Preface

I have been designing products and, in particular, processes my whole life. I had often wondered whether I could turn the resulting experience into scientific knowledge. In the late 1990s, I discussed this idea with Prof. Ger Maas from Eindhoven University of Technology (TU/e) and he thought it was very interesting. We recognized in each other a passion for designing processes involving people within organizations. Ger focuses on strategy and thinking outside the box, while I strive to find opportunities and create the right conditions for collaboration. What each of us had until then been doing intuitively, namely encouraging groups to work together, became our main objective when designing teaching programs, tackling research questions, organizing symposia and designing workshops.

The people who were involved in these activities had similar interests. I'm grateful for their enthusiastic and inspiring input. I will mention a few of these people below.

Together with Nico Hendriks, I was part of the Industrial Flexible and Demountable (IFD) Today research group. The objective was to design, build and test the first version of an industrial, flexible and demountable construction system. Nico had set up this innovative research program in partnership with a housing association, a number of construction firms and TU/e education and research. He gave me the opportunity to observe how different participants in that process used each other's input. My area of focus within the IFD Today project was designing installations. This is how I came into contact with Paul Rutten. My observations during the IFD Today project strengthened Paul's conviction that in order to make optimum use of the specific expertise of building physicists, it is important that they be better equipped to work together with other disciplines. For this reason, we developed the 'Creativity and innovation in design teams' tutorial. For years, it was a compulsory subject in the TU/e Built Environment faculty program.

Together with Jos van Leeuwen and a little later with Bauke de Vries, I developed and taught the 'Collaborative Design'. tutorial. In this case, the emphasis was more specifically on learning to choose and systematically employ modern communication techniques – particularly in situations where designers are communicating with one another remotely. By working with Jos and Bauke, I learned how to organize virtual meetings.

The 'FutureSite' graduation studio was a learning community of master students, lecturers and business professionals. The professionals Bert van Eekelen, Hans Kleine and Jules Huyghe had the courage to contributed ideas about working practices and tried them out in this 'laboratory' environment. This gave me insight into processes of learning together – which was the inspiration for my research.

From the literature, I discovered that Suzanne Verdonschot was conducting research into design principles for knowledge productivity. Together, we incorporated these design principles into a simulation game. We tried out the game during a VDCM symposium and then evaluated it by means of a survey.

At the BAM Group, Peter Lapidaire gave me the opportunity to conduct workshops on creative thinking. This helped generate the support needed to develop a course of study. Tim Welling included this course in the BAM Business School's program. The course was fleshed out further with the help of Cécile Claessen. Insights into the area of creative thinking and designing together were enriched with socio-psychological principles thanks to Cécile's input. In this way, the "Thinking more creatively in tender teams" course continued to develop. Together, we taught the course 10 times. This course established a platform for validating design principles in a systematic manner.

I learned writing articles for scientific journals in the publication class taught by Annelies van Bronswijk. I also learned a lot from the input and feedback of Lilliana Abarca Guererro, Wim van den Bouwhuijsen, Gaby Abdalla, Ruben Favié, Michiel Brink and Remy van der Vlies. The publication class was an activity of the PEBE research group, which also included Paul Spierings and Cor Pernot. This research group was an inspiring and supportive working environment for me.

Dhun Krishna Prasad-Lal, Astri Keizer, Kristin Zaal, and Maria Jennings-Kamphuis helped me write English text for my research. Under the guidance of Dhun and Astri, I gained a great deal of experience giving English presentations.

When conducting the research, I was greatly assisted by Janet van Laar, who scheduled appointments with the people to be interviewed and entered the research results into SSPS. Additionally, Thomas Paauwe provided good advice on analyzing the research data. I received professional support from Marly Juressen regarding the references in EndNote.

The quest for an appropriate 'design science research' methodology was long and difficult. During that time Isabelle Reymen, as co-supervisor, supported me in a professional and committed manner.

Jan Buijs, a member of the doctorate committee, provided extensive and constructive comments on the first version of the manuscript. Unfortunately, he did not live to see the results of his input.

Throughout all of these research activities, my supervisor Prof. Ger Maas was there in the background to act as a wise and safe sounding board. With his probing and inspiring questions, Ger gave me the space to refine my course.

I took my creative restlessness home with me too. There, Marjan was a mirror for critical reflection and a rich source of ideas as we share a passion for experience-focused learning.

Table of Contents

The Bricklayer

The Bricklayer came
He brought his brown stones
He said: ‘I’m building houses
I’m not building homes
I have to make walls
So please leave me alone’.

When I came back at the end of the day
He (had) finished four walls
No window, no door, no ray of light
He was inside
He could not get out anymore

Why you’re inside?

The Bricklayer said
‘I brought my brown stones
I’m not building houses
I’m not building homes
I’m building a prison
Although I am free
It’s only for me’.

‘Everything I do is made by hand
I came from a faraway land
Where everything is handmade
I’m a man with a traditional trade’.
Why I’m inside?

I said: ‘Next time you leave a hole in the wall
A window, a door, no matter how you call it
A simple way of walking outside
Or letting me in’.

(Text: Henk Hofstede. Publisher Nitsongs)

Chapter 1
From field problem to research objective

1.1. Introduction
The Architectural Engineering and Construction (AEC) sector clearly needs improvement in the area of creative and collaborative working. Professionals in this field find it difficult to manage the current developments in this sector.

This study presents a solution to this *field problem* by developing and evaluating a creativity facilitation course that will teach the professionals better ways to plan, organize and conduct face-to-face design meetings. The course (a *design solution*), is based on a set of normative ideas and propositions that are grounded in research and presented in the form of *design principles*.

The study also includes a reflection and discussion of creativity facilitation that contribute to the further development of existing knowledge within the following scientific domains: *building design management*, *small group creativity*, and *design science research*.

This chapter will first explain the current developments in the AEC sector that have helped to identify the necessity of improved creative and collaborative working. Thereafter, this field problem, available solutions and research needs will be further explored. Subsequently, based on the research problem, a research approach will be chosen and described in greater detail. Finally, the research objective will be stated.

1.2. Developments in the AEC sector
Better creative and collaborative work processes are necessary to respond to current developments in the AEC sector. These developments include increased mechanization and automation of the workforce, a greater demand for improving performance, more performance-oriented tenders, and a stronger focus on identifying the needs and values of both the client and the user. These four developments will be described in more detail below.

The first development is increased mechanization and automation of the workforce on the construction site, which is desirable because it lightens the physical workload of construction workers and improves their safety and health (Van Gassel & Maas, 2008). This transition on the construction site requires intensive collaboration between architects, product and process designers, builders, consultants, suppliers, etc.

A second development is a greater demand for improving performance. This development is a direct result of demands that have been made by clients and society. Approaches that can be used to achieve the desired performance include the following: *performance management*, which involves cooperation, strategic partnering, collaborative engineering, collaborative planning, supply chains and design build; *construction management,* which involves risk management, decision support systems, failure costs, value management, bench-marking and health & safety; and *construction engineering,* which involves industrial construction, sustainable construction, constructability, mass customization, intelligent building and renovation. A driving force for this transition is the application of human-machine technologies such as mechanization, robotization and automation of the construction processes. This approach was explored in 2001 when the CIB Task Group TG27 presented the study “Human-Machine Technologies for Construction Sites” (Maas & Van Gassel, 2001) and later when the International Symposium on Automations and Robotics in Construction (ISARC) offered a presentation in 2003 entitled “The Future Site”. Maas and Van Gassel (2005) provide an overview of this development in their article “The influence of automation and robotics on the performance construction”. This article was published in the well-known journal *Automation in Construction* (AUTCON), and has been integrally reproduced in Appendix A.

The third development is more performance-based tenders and performance-based thinking, which are elaborated on in a European research project called Performance Based Building (PBB) that was done by the International Council for Research and Innovation in Building and Construction (CIB). The conclusion of this research was that there is a growing need for user-friendly methods of capturing or defining user needs and client requirements with regard to performance-based tenders. This conclusion resulted in a growing awareness that performance-oriented tenders such as the Most Economically Advantageous Tender (MEAT) and Public Private Partnership (PPP) not only demand more collaboration between designers and builders, but also between principals, users and society, all of whom are demanding more value for their money. The ‘lone designer’ is becoming a thing of the past (Dorst, 2006). These developments are making the process of Design, Build, Finance, Maintain and Operate (DBFMO) increasingly complex, particularly within the context of a sustainable and healthy society. The providers of performance-oriented tenders are assessed to a great extent on their ability to show conceptual, creative, innovative and problem-solving skills (Visser, 2006).

A final development is that nowadays designers also need to have a stronger focus on identifying the needs and values of both the client and user. In recent decades, society has undergone a process of individualization that Schnabel of the Netherlands Institute for Social Research [Sociaal Cultureel Planbureau (SCP)] describes as a process of increasing independence among individuals in society. The following demographical statistics illustrate this point. In 2004 one in three households was a single-person household, but in 1960 that ratio was one in eight (Schnabel et al., 2004). In addition, it has been projected that over the next five decades, the population of those 15 to 64 years of age in Europe will decrease from approximately 333 to 283 million people, and over the same period, the median age of the total population will increase from approximately 40 to 48 years of age. Globally, the median age of the population will increase by about 5 years between 2005 and 2025 (Giannakouris, 2008). According to the European Construction Technology Platform (ECTP, 2005), supporting active aging in the construction sector plays a key role in a number of the application domains of gerontechnology: housing, mobility, communications, leisure and work. The World Health Organization (WHO) has identified active aging as a process of optimizing opportunities for healthy participation and security in order to enhance the quality of life as people age. Identifying these opportunities requires an in-depth study of the social environment of individuals from these generations.

The four developments in the AEC sector explained above show that designers and users need to discuss how they should explore the possible solutions during the tender, design, production and maintenance phases. These discussions are taking place during design meetings, workshops, and vision development meetings. New forms of creative collaboration and teamwork allow designers and users to benefit from each other's knowledge, skills and experience.

Managing or facilitating these creative processes on the small-group level requires suitable work methods and creative leadership.

1.3. 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 enable it to be solved (Van Aken & Andriessen, 2011). At this moment, professionals, stakeholders, clients and users in the 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[1] are sometimes engineered in practice. It is important to ask questions that can help determine whether the following issues have been sufficiently addressed: preventing thermal bridging, labor-friendly delivery, positioning and fixing (Maas, 1994) of building components on the building site, and environmentally-friendly ways of dismantling building components. 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 (*Verslag studiedag bouwknopen 4 februari 1993*, 1993). In proposition three of his Ph.D. research, Olie (1996) characterized this problem of collaboratively designing building joints as follows: "Good joints in buildings depend on good connections between parties." See Figure 1.1.

Figure 1.1. Many joints in buildings but no connections between parties.

For this study, the field problem can be 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 or 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" (Wilkinson, 2005). 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,

[1] The term 'building joints' is described in the International Organization of Standardization (ISO) norm 7727:1984 – Principles for jointing of building components – Accommodation of dimensional deviations during construction (http://www.iso.org/iso/catalogue_detail.htm?csnumber=14563).

(v) formulating solutions, (vi) exploring acceptance and (vii) formulating a plan (Puccio, Mance, & Murdock, 2011). Meetings in the AEC sector are primarily conducted in a face-to-face setting. Rhoades and O'Connor (1996) stated that "In face-to-face groups the affect, or emotion, experienced by group members has an impact on the group's cohesiveness"; 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*. Before dividing the main aim of the course into sub-aims, the following aspects of successful creativity facilitation deserve further attention.

(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. Bucciarelli (2002) calls these conventions and customs 'the object world'. 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. Participants of a meeting form by definition no team; if a participant is unable to attend, he/she may send a replacement without announcing this in advance, and sometimes they will even benefit more from the meeting than if they were able to attend.

(ii) Involved facilitation

In most meetings, the project leader chairs the meetings by focusing on his/her own issues, and is not engaged in the contributions of the participants. In order to avoid this lack of participation, a leader with an enterprising spirit and a proactive attitude 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 have often 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. They must learn how to use scientific prescriptive statements, which in this study a set of design principles. A safe environment, such as a course can be very helpful in this regard.

Based on these aspects of successful creativity facilitation, the sub-aims of the creativity facilitation course that is based on a set of design principles can be described as follows (key values of sub-aims one to five are placed in parentheses):

i. Oriented to the AEC sector. The course participant will be able to facilitate creative and collaborative face-to-face meetings that are specific to the AEC sector. (Responsibility, Customer directed, Letting go)
ii. Involved facilitation. The course participant will be able to plan, organize and conduct design meetings and will be involved with the problem. (Engagement, Enterprising spirit, Proactive)
iii. Stimulating cooperative learning. The course participant will show creative leadership behavior that invites participants to learn and make use of each other's knowledge. (Empathy, Enterprising spirit, Proactive)
iv. Using varied skills and intelligences. The course participant will be able to use the varied skills and types of intelligences of the participants. (Playfulness, Imagination, Inventiveness)
v. Creating an open culture. The course participant will be able to address the problems and solutions presented by the participants, and stimulate them to respect each other's suggestions and solutions. (Transparency, Reflecting, Respect)
vi. Consulting a set of design principles. The course participant will be able to work with useful knowledge such as a set of design principles that are based on scientific research and that help the participant plan, organize and conduct a wide range of design meetings.

The skills outlined above can be taught with a course that has been developed using a suitable set of prescriptive statements or design principles. Before developing a creativity facilitation course based on design principles, it is useful to first explore which statements are available and into which courses these statements can be incorporated.

1.4. Exploring prescriptive statements and courses

It is beneficial to first explore which prescriptive statements are available. To do this, the research scope 'step models and process frames' will be used, because it can be applied to a broader area of study. Then (creative) facilitation courses with incorporated step models and process frames will be explored. The last section will present conclusions about available step models and process frames and it will identify courses that can potentially solve the field problem.

1.4.1. Step models and process frames

This section will identify and summarize some of the available step models and process frames from the scientific domains of *building design management* and *small group creativity* that can support professionals as they work to improve creative and collaborative working in meetings. These step models and process frames have largely been chosen using the following criteria: they are based on the acquired experiences of the researcher while conducting research and also on the educational activities of the researcher; they have been developed in the professional domains of 'industrial design' and 'industrial engineering and innovation'; they have used classic approaches; and they have also used recently developed approaches.

Each step model and process frame will be explained and, if applicable, the explanation will identify which of the following criteria matches best: (i) oriented to the AEC-sector, (ii) involved facilitation, (iii) stimulating cooperative learning, (iv) using varied skills and intelligences, (v) creating an open culture, and (vi) consulting scientific prescriptive statements. See section 1.3.

The following are the identified step models and process frames:

1. Creative Problem Solving (CPS). Steps: orientation (indicating the problem), preparation (gathering pertinent data), analysis (breaking down the relevant material), hypotheses (compiling alternatives with new ideas), incubation (pausing periodically, to allow for illumination), synthesis (pulling the pieces together), verification (judging the resulting ideas) (Osborn, 2011) (p. 125). This step model was developed in the 1950s and it is useful for including separate diverging and converging phases.
   - The CPS method is supported by extensive scientific research. The focus is on (vi) consulting scientific prescriptive statements.
2. The COCD approach. Het Centrum voor het Ontwikkelen van het Creatief Denken (COCD) [The Centre of Development of Creative Thinking] deepens and communicates knowledge about creative thinking. The body of thought that incorporates the COCD approach has been described in the publication *Creativity TODAY* (Byttebier & Vullings, 2007). In this approach, the creative process follows the following phases: starting, diverging and converging. COCD also developed the converging tool known as the COCD box, which is a selection technique that classifies the generated ideas into three groups: known ideas (NOW.), feasible ideas (WOW!) and ideas that are not yet feasible (HOW?).
3. The COCD approach focuses on (iv) using varied skills and intelligences and on (vi) consulting scientific prescriptive statements.
4. The Gemeentewerken [Public Works Department] has developed a model of the design process (*Een model van het ontwerpproces: het ontwerpproces op een rij gezet*, 1977). In this model, three activities are always present: analyze the problem and gather information about wishes, create a solution, and check the solution with

the results of the analyses. Each phase of the building process can be explained using the same model.

5. Methodical design. This design method is comprised of three phases: a problem-definition phase (drawing up requirements and wishes), a phase to determine the method (setting up a morphological matrix, conceiving a method and choosing a structure), and a design phase (elaborating on the chosen structure) (Van den Kroonenburg & Siers, 1992). Zeiler and Savanović (2012) expanded on this approach with the help of the theory of 'space of concept and space of knowledge' (C-K) described by Hatchuel and Weil (2003). In this method, four different operators explain the whole design process: (K→C) disjunction, (C→K) conjunction, (C→C) expansion by partition or inclusion, and (K→K) expansion by deduction or experiment. This design method is a very structured process and the tools to choose solutions are thoroughly described.
   - This method is very suitable for the AEC sector, specifically for solving its engineering problems. The focus is on being (i) oriented to the AEC-sector and on (vi) consulting scientific prescriptive statements.
6. Creative session scenario used during the Eindhoven University of Technology (TU/e) master lecture "Creativity and innovation in design teams". The steps in this scenario are preparation, focus, generating ideas, selection, and action plan (Rutten & Van Gassel, 2003). This rhythm was used during the lectures from 2003 to 2013 and was the format that the students used to design their training sessions. This scenario was the basis of many types of design meetings and included a phase that had the facilitator reformulate the question.
   - This scenario allows the facilitator to use creativity techniques to address the varied skills and intelligences of the participants of a session. The focus is on (iv) using varied skills and intelligences.
7. Method for Holistic Participation (MHP). Schmid developed this method at the TU/e to encourage teamwork during educational exercises for architectural assignments. The following are the steps of MHP: explaining the assignment, introducing the team members, listing the themes, planning, working in groups, transferring and discussing respective information, changing roles, working out decisions, and ultimately presenting and evaluating the results with an exhibition (Schmid & Wouters, 1996). At the end of the fifties, Wachsmann (1962) developed this method and explained it extensively in the book *Wendepunkt in Bauen* [Turning point in building]. This method offers insights into the roles of diverse actors during the building process. Human dynamics interactions play a substantial role in this method as well.
   - Focus on (v) creating an open culture.
8. Systematic Inventive Thinking (SIT). This method is based on an existing product and/or process. It consists of the following steps: describing the product and/or process, defining the problem, describing the internal and external product and/or process parts, developing virtual ideas based on five SIT creativity techniques, transforming them into feasible ideas and choosing one of them. These process steps were developed for a special training course in creative facilitation and based on a publication from Heere, Van der Heijden, Van Logtestijn, and Mandour (2005). The method uses five,

well-thought-out creativity templates: attribute dependency, forecasting matrix, replacement, displacement and component control. The SIT method is an adaption of the Creativity Template Theory of Goldenberg and Mazursky (2002). This method is very suitable for engineers because it has a structured approach.

⇢ Focus on (i) oriented to the AEC-sector,

9. Reflective practice. The reflective practice is based on the following design activities: naming (sharing thoughts between the team members), framing (creating a shared perception of the design tasks), moving (solving the design problem) and reflecting (on the design activities) (Valkenburg, 2000). This descriptive model for design as a reflective practice is a very useful basic tool for developing prescriptive methods.

   ⇢ This method is supported by extensive scientific research. Focus on (vi) consulting scientific prescriptive statements.

10. The Delft Innovation Model (DIM) for innovating in companies is characterized by the following elements: "a circular process view; five stages, each stage is visually similar in building blocks, shape and size; it is seen from the company's view; and it is connected to the different contexts the company is working on" (Buijs, 2012). There are five stages: product use, strategy formulation, design brief formulation, development, and market introduction. Evaluation between the stages is very important. This model is based on knowledge developed in the domain of design thinking, such as "a problem is the start of the process", which was mentioned by Roscam Abbing in (Buijs, 2012) (p. 105).

    ⇢ This method is supported by extensive scientific research. The focus is on (vi) consulting scientific prescriptive statements.

11. Integrated Creative Problem Solving (iCPS), developed by Buijs and Van der Meer (2013) (p. 82), Delft University of Technology. The conceptual model of iCPS consists of four interrelated sub-processes: project management, content finding, information finding, and acceptance finding. The sub-process project management involves the organizational aspects of conducting and managing not only a specific creative session, but also preparation and closure activities. A project generally starts with this sub-process and can be followed by any of the other sub-processes in random order. The sub-process of (external) information finding is an activity that usually takes place between the sessions.

    Tassoul and Buijs (2007) expanded on the CPS model with a clustering step between diverging and converging.

    ⇢ iCPS is supported by extensive scientific research. Focus on (vi) consulting scientific prescriptive statements.

12. GPS Brainstorm Kit, published by Flanders District of Creativity in Belgium (Flanders DC, 2005). This is a guide for businesses that offers tips on how to organize a GPS brainstorm session. It details four steps: prepare for the session; conduct the session; after the session, write a report and make a definite choice; and finally, follow the other steps in the innovation process. GPS advises facilitators to invite session participants from different departments within the organization (2/3 internal) and also from outside the organization (1/3 external).

    ⇢ The guide promotes an open culture. The focus is on (v) creating an open culture.

13. Crenovatie, an innovation project for small and medium-sized enterprises in the Netherlands, published a guide called *FF Brainstormen* [FF Brainstorming] that can be used as a reference for preparing and conducting creative sessions (Van der Meer & Heijne, 2012). The guide outlines five phases: before you start, intake, preparation, the session itself, and finalizing + follow-up. Crenovatie states in the guide that the role of the problem owner and of the session leader is not the same.
    - For the criterion of (iii) *involved facilitation*, the skill that will be learned is to have one person play the role of problem owner and then session leader.
14. Value Design Canvas. This is a tool for collaborative design that was developed by Pelin Atasoy at the Eindhoven University of Technology. The following are the stages of the workshop: "a design domain analysis with user control perspective, envisioning user experience, business process concept design, concretization with scenarios and product features, and communication of the idea based on a template" (Atasoy, Bekker, Lu, Brombacher, & Eggen, 2013) (p. 2).
    - The design of the Value Design Canvas tool has been aimed, among other aims, on creating "a bond within the group" and allowing "the participants to build on earlier comments and each others' ideas" (p. 2). The focus is on (iii) stimulating cooperative learning.
15. The FourSight Model. This model, developed by Puccio from the International Center for Studies in Creativity in Buffalo, NY USA, includes the following steps: clarify (explore the vision, gather data, and formulate the challenge), ideate (explore, group and converge ideas), develop (formulate and evaluate solutions), and implement (explore acceptance and formulate a plan) (FourSight, 2011). The FourSight model also distinguishes four types of participants (i.e. ideators, clarifiers, implementers and developers) and helps the facilitator to get the participants to collaborate with each other better.
    - The model is supported by extensive scientific research. The focus is on (vi) consulting scientific prescriptive statements.
16. Frame innovation ("create new thinking by design"). Dorst (2013, 2015) presented a nine-step model for frame creation in design, based on the general structure of a reasoning process: WHAT + HOW leads to OUTCOME. This design abduction starts with the idea that we know only something about the nature of OUTCOME (in terms of desired value) and need to develop new ideas and concepts about WHAT and about HOW. The following are the nine steps: archeology, paradox, context, field, themes, frames, futures, transformation, and integration. The deeper principles of the frame creation approach are the following: attack the context; suspend judgment; embrace complexity; zoom out, expand and concentrate; search for patterns; sharpen the frames; be prepared; create the moment; and follow through.
    - This model is based on long-term scientific research. The focus is on (vi) consulting scientific prescriptive statements.
17. *Slimbouwen* [a paring down process] process. One of the elements of this process is that the following four buildings parts have been built successively and independently: the shell, skin, installations and finishing (Lichtenberg, 2005).

- ⇢ Slimbouwen strives to create an optimal integral design by stimulating trust among participants and having them take responsibility for each other. The focus is on (v) creating an open culture.

18. Collaborative Design (CD) Workshops. Quanjel (2013) has developed an approach for workshops to stimulate interaction and knowledge exchange between practitioners. For the CD Workshops, a model has been developed and there is a protocol for how to use this model. The CD Workshop takes two days and the program is described in detail.
    - ⇢ The CD Workshop is suitable for (i) the AEC sector to exchange knowledge between the practitioners and focuses on (iii) stimulating cooperative learning.
19. Keursten, Verdonschot, Kessels, and Van Rooij's (2007) developed eleven design principles for knowledge productivity[2]. These principles are used in interventions for those who are active in innovation practices. The principles are based on case study analysis and literature research (Verdonschot & Keursten, 2006). These design principles offer "the designer a supporting framework to balance between the rational and systematic approaches required to achieve breakthroughs in complex processes" (Verdonschot, 2009).
    - ⇢ These design principles are supported by extensive scientific research. The focus is on (vi) consulting scientific prescriptive statements.

1.4.2. Creativity facilitation courses

In this section, a number of Dutch-language courses that teach the skills for facilitating a design meeting will be briefly explored. These courses were chosen if they met the following criteria: the researcher followed or gave the course, visited a session of the course, conducted research to gain insight into the effect of the course, and knows the trainers, and the course meets the qualifications of the International Association of Facilitators (IAF). The IAF describes core facilitator competencies and provides to successful candidates the professional credential of Certified Professional Facilitator (CPF). See the website of IAF www.iaf-nederland.nl. The approach of IAF is that the facilitator plays a substantially neutral role and that he/she has no interest in a specific result. A number of course providers prepare facilitators for the IAF certificate.

The sources of this overview are the announcements and reports that the organizations distribute. If a course is based on one or more step models and process frames listed in Chapter 1.4, this will be additionally mentioned.

1. The course "Stimuleren van creativiteit en innovatie" [Stimulating creativity and innovation] is offered by Schouten and Nelissen (2015) and teaches facilitators to organize successful creative sessions. The course aims to enhance the following competences: creativity/inventiveness, flexibility, presenting, result driven, and self-directing. The course helps the participant gain more insight into his/her facilitation style.

[2] In Chapter 4, "Developing a creative facilitation course based on design principles", more details about design principles for knowledge productivity will be mentioned.

- The effect of these courses has been studied by researchers at Utrecht University. They measured the effects of a number of courses on personal resources and commitment (Kok, 2010). The study did not focus on specific creativity skills.

2. The Centre for the Development of Creative Thinking (COCD) offers a course called "TOP-facilitator". After finishing this course, the participant will be more confident and relaxed in front of the group and will be aware of his/her contribution and quality. Moreover, the participant will learn to design the creativity process. The "Theory U" (Scharmer & Pel, 2010) has been used as a guide. This course is suitable as preparation for the IAF certificate.
   - The course is based on the COCD approach.
3. The Delft University of Technology' Industrial Design Engineering department offers a course called "Creative facilitation". The study goal is described as follows: by the end of the course, students will have extensive experience in planning, conducting and participating in creative processes. During the second part of the course, students develop and lead a creative session on their own. The issues of the sessions range from Product Design to New Business research (Tassoul, 2014). The study material is the book *Creative Facilitation*, written by the course leader Tassoul (2006).
   - The course is based in the COCD approach and iCPS.
4. For the past ten years, the Eindhoven University of Technology's Built Environment department has offered a workshop entitled "Creativity and Innovation in Design Teams". The learning objectives are to increase knowledge of creative thinking, gain insight into the use of creativity techniques, and gain insight into how to best plan and control an architectural meeting. The course followed the book *Creativity TODAY* written by Byttebier and Vullings (2007). See also Chapter 4, Table 4.11.
   - The course follows the COCD approach.
5. The course provider '2 Facilitate 4 best results' offers the course "Facilteren Practitioner" [Facilitating practitioner]. The course aims to teach professionals how to facilitate workshops. It addresses questions such as "How do you manage the collaborative work process of team members?" and "How do you help employees share knowledge with each other?"
   - This course prepares facilitators for the IAF certificate and does not focus on a special prescriptive statement.

1.4.3. Concluding remarks

The survey of the step models and process frames in Chapter 1.4.1 has led the researcher to the conclusion that no one, specific solution is suitable to be used as a set of design principles upon which to base the course development. Moreover, it is clear that there are many aspects that can relate to the criteria mentioned in Chapter 1.4.

The survey of the creativity facilitation courses in section 1.4.2 indicates that three of the five courses are mainly oriented towards professionals who are seeking to improve their personal skills, and who work for various companies, governments and institutes or who work as self-employed facilitators. The other creativity facilitation courses are a part of a university curriculum and are given with lectures. These courses are mostly based on scientific research.

However, the available solutions to the field problem do not actually match the criteria for choosing the appropriate course. Therefore, the generic approach that will be used to address the field problem is to develop a creativity facilitation course based on design principles. This course will train the (design) process manager or project manager to find solutions by collaborating with a broad variety of professionals. This course should meet the specified criteria and should focus on learning how to plan, organize and conduct a design meeting.

The development of the course should also provide new knowledge and must meet the needs of the building design management and small group creativity domains. In the following section, these needs will be investigated.

1.5. Research needs and research problem

The needs for research in the building design management and small group creativity domains have been identified in the literature and also by the researcher of this study. These domains will first be described, and then the research needs will be presented. This section will conclude with the formulation of the research problem.

1.5.1. Building design management domain

Gray and Hughes (2001) define building design management as "Coordinating the design task to ensure that information of the appropriate quality is delivered within the project time-scale to meet the needs of the design, manufacturing and construction process" (p. 195). The Institute of Interdisciplinary Design for the Built Environment (IDBE) finds that "it is important to advance understanding of the ways that designers with different disciplinary expertise are able to work together, collaboratively in teams and the study of how design is organized in practice continues to be examined through research"(www.idbe.arct.cam.ac.uk). In a review of current literature on design management in the building process, Knotten, Svalestuen, Hansen, and Lædre (2015) concluded that building design management involves managing both the production of the designs and the creative minds of designers. They insist that "There must be enough room for creativity so that a building project can evolve to serve clients' needs" (p. 120). These three approaches emphasize the management of interdisciplinary design processes with the planning, organization and production of a building task. These three approaches do not seem to ascribe the following definition of design management given by the Dutch Design Management Network (DMN): "an increasingly critical factor in achieving business and organizational goals in the most inspiring and efficient way" by focusing on products, services and communication power (www.dmnetwerk.nl/). Blaich in Kootstra and Van der Zwaal (2006) stated that "Design management is the implementation of design as a formal activity program within the organization, by communicating the interest for design for the long-term aims, and coordinating the design resources on all organization levels, to realize organizational objectives" (p. 149). The last two approaches do not fit within the definition of design management used in this study.

1.5.2. Small group creativity domain

Small group creativity is a research domain that is part of the behavioral science field. According to Sawyer (2003), group creativity involves two or more people who are creating together at the same time. He identified three characteristics of group creativity: improvisation, collaboration and emergence. A small group consists of between 3 and 20 individuals (Beebe & Masterson, 2006). In his scientific work, Paulus of the University of Texas (USA) spent a great deal of time trying to determine "how to structure creative processes in such a way that groups can actually benefit from their creative potential" and in the process he discovered many factors that influence group creativity (Harms & Van der Zee, 2013). In their overview study, Paulus and Nijstad (2003) concluded that groups are capable of highly creative performance that is even more creative than the performance of individual group members. To attain this high level of group creativity, a (facilitated) group interaction is required in some of the stages of the creative process. Eric F. Rietzschel (2015) studied the creative paradox of structure and autonomy. To stimulate creativity, structure and restrictions can be helpful, because they decrease the task complexity. The extent of the structure and restrictions will be stipulated by the needs of the individuals; one person may need more clarity, while another might desire more autonomy. A facilitator must be aware of such diverse needs of the participants during a design meeting. The *Handbook of Organizational Creativity,* edited by Mumford (2012) (pp. 707-725), provides practical ideas about how design managers can encourage creativity and innovation in their work fields. Nijstad and Stroebe (2006) have developed a cognitive model of idea creation in groups. The model is called Search for Ideas in Associative Memory (SIAM). This controlled, associative process comprises two steps: knowledge activation and idea production. Important determinants are turn-taking, aid by others and failures that influence brainstorming persistence, satisfaction and enjoyment.

1.5.3. The needs identified in literature

In the existing literature that has covered the two scientific domains mentioned above, researchers have identified needs that warrant further research. The following are some needs that can be identified with the key words group creativity, collaborative working, and performance-based building:

- With the help of the generic model of group creativity, Paulus and Nijstad (2003) formulated five research questions: "What are the relevant inputs group members bring to their task?; Under what conditions are individual inputs contributed in an optimal way?; How do the contributions of other group members affect individual-level cognition, motivation, and emotion?; How are individual contributions combined to yield a creative group response?; and Under what conditions does group creativity affect the environment of the group?"
- More bridging research should be conducted regarding project management and organizational creativity to examine the relationships between these area (Paletz, 2012) (pp. 421 and 450).
- There is also a need for research on how to structure face-to-face design meetings and on the appropriate use of guidelines for trained facilitators to enhance group creativity (Paulus, Dzindolet, & Kohn, 2012) (p. 349). For example, researchers should

ask, “how can I elicit contributions from various professionals and intelligences in a collaborative practice?”

- In 2005, the International Council for Research and Innovation in Building and Construction (CIB) published the international, state-of-the-art report entitled Performance Based Building (PBB). The publication was funded by the European Commission and 70 worldwide organizations participated (Becker & Foliente, 2005). In this publication from Becker and Foliente, Gipson (1982, p. 4) defined PBB as follows: “The performance approach is [...] the practice of thinking and working in terms of ends rather than means” and “It is concerned with what a building product is required to do, and not with prescribing how it is to be constructed.” The CIB report describes the research needs as follows: “There is a glaring need for systematic and user-friendly methods of capturing or setting user needs and client requirements. This includes guidance on process methodology (Paletz, 2012) and technique (e.g., charrette or value management method), that facilitate the process of capturing requirements.”
- In 2011, the European Commission, Directorate-General for Enterprise & Industry initiated the “Sustainable Competitiveness of the Construction Sector” study. A challenge for this sector is to improve “skills such as problem orientation, problem solving, communication, entrepreneurial skills, and design, are critical to cross-occupational collaboration in work teams and to exploiting value-added creation at the firm level through employee and market-driven innovation” (ECORYS Research and Consulting, 2011).
- A building assignment is a complex task that demands creative processes and the cooperation of teams if added value is to be achieved for users and society. In addition, “this co-creation has to be organized in another way than just dividing the tasks and managing the interfaces” (Van Eekelen, 2011) (p. 52).
- In the study “De Dokwerkers” [The Dockers], Van Eekelen, Schnieders, and De Wilde (2014) came to the conclusion that the cooperation that occurs during planning development and during administrative decision making for complex projects still involves a human element. They state that “The human element means that one must get to know, understand and respect each other in order to achieve results”. Based on experiences with complex planning and development in a city, Van Eekelen (2015) came to a further conclusion that current construction management and engineering education pays little attention to developing a design approach that is focused on actual business cases and leadership. New professionals need skills to meet these developments.

1.5.4. The needs identified by the researcher

As the researcher of this study, I have spent the last thirty years participating in professional activities such as research and teaching projects in the AEC sector and I have published multiple documents on this subject. The information I have obtained from my experiences with three specific projects is as follows:

- The design process of an industrial construction system requires “co-operation and a multidisciplinary approach. Matters such as design tasks, choice of designers, design tools and expected results must be considered during the course of the design process, and design meetings must be organized” (Van Gassel, 2002a). After carrying out a study called “construction-friendly design”, I began to develop a guideline for working together that would stimulate professionals to understand each other during a meeting (Van Gassel, 2002b).
- I presented lectures and workshops about mechanizing the workforce for construction work at the site, and about easing the daily activities for aging-in-place situations. First, it is crucial to formulate the problem by analyzing the activities on the construction site or in the private residence, and then, to develop solutions in a methodically way (Van Gassel, 1999b; Van Gassel & Van Bronswijk, 2010).
- I gave lectures and workshops about collaborative design. Evaluations of these presentations indicated that “initiating and leading multi-disciplinary collaboration is a vital competency that needs to be learned by doing” (Van Gassel, Van Leeuwen, & Den Otter, 2004).

1.5.5. Research problem

The needs described in the previous two sections show that there is a gap in the knowledge and skills that professionals possess regarding the best way to facilitate creative and collaborative working during design meetings. To fill this gap, a specific creativity facilitation course that is based on a set of validated design principles must be developed. The main-aim and sub-aims of the course are listed in Chapter 1.3.

Therefore, the research problem can be formulated as follows: *Researchers lack insight into the parameters that can be used to describe design meetings and the way in which a facilitation course based on a set of design principles can be used to improve creative and collaborative working during face-to-face design meetings in the AEC sector.*

In the following section, a research approach will be chosen and a research objective will be formulated to realize the proposed solution.

1.6. Research approach and research objective

A suitable research approach is necessary to solve the research problem. First, a research approach will be chosen and thereafter, the research objective will be formulated.

To solve a research problem, an explanatory science research approach, a design science research approach or a design research methodology (DRM) can be chosen. With the first approach, the research is driven by pure knowledge problems, such as how heating changes the structure of material, and whereby “the validity of this knowledge is justified on the basis of its descriptive and explanatory validity” (Van Aken & Van Fenema, 2014). The second approach is driven by developing knowledge that can be used to solve field problems in a generic way (Van Aken & Andriessen, 2011). The third approach, DRM (Blessing & Chakrabarti, 2009), develops and validates knowledge, methods and tools founded in theory with the aim to improve the design of products. The design science research approach has been chosen for this study because it is suitable for designing social processes and it meets the needs and developments in the AEC sector. As an engineer, I like the design science research because my experiences with various types of research and teaching projects can be used as a source for finding new knowledge that can help to develop a solution to the field problem.

Design science research links practices with research findings (Romme & Endenburg, 2006) by using design principles and design solutions. Design principles are "normative ideas and propositions, grounded in research, that serve to design and construct detailed solutions" (Romme & Endenburg, 2006). A scientific design proposition expands on this by following the so-called CIMO-logic: "In this class of problematic Context (C), use this Intervention type (I) to invoke these generative Mechanisms (M) to deliver these outcomes (O)" (Denyer, Tranfield, & Van Aken, 2008). "Design solutions are representations of the practices being redesigned with the help of the design principles" (Van Burg, Romme, Gilsing, & Reymen, 2008). This research approach uses the experiences of the Design Science Research Group (DSRG), in conjunction with the *Handboek ontwerpgericht wetenschappelijk onderzoek* [Handbook for design-focused scientific research] (Van Aken & Andriessen, 2011) and the public lecture *Practisch relevant* én *methodisch grondig?* [Practically relevant and methodologically thorough?] (Andriessen, Greve, & Butter, 2014).

Assessing the validity of design science research outcomes is not the same as conducting explanatory research. Generally, the interventions, the system of interest, and the desired outcomes from design science research are too complex and the usual methods of quantitative research are not suitable. A better approach in this study would be to strive for a pragmatic validation (Van Aken & Van Fenema, 2014). A *pragmatic validation,* according to Kvale and Brinkman in Van Burg (2011) (p. 151), is "the extent to which the research creates guidelines that generate the desired outcomes when those guidelines are actually applied (within the specified application domain)". Similarly, Rescher describes in Worren, Moore, and Elliott (2002) that "the pragmatic validity of knowledge can be judged by the extent to which goals or intended consequences can be achieved by producing certain actions or using particular instruments" (p. 1228).

The solution to the field problem is a design solution, namely a creativity facilitation course that is based on a set of validated design principles. In the chosen research approach the course is a *technological design* [proefontwerp], "a design that has been produced through the application of appropriate theoretical knowledge and methods, accompanied by scientific account and documentation" (Eindhoven University of Technology, 2014).

This study is practice oriented because the research question was prompted by professional practice (Andriessen et al., 2014). However, the result will not only lead to improved creative and collaborative working during design meetings, but also to further developments of existing scientific knowledge in the fields of *building design management*, *small group creativity* and *design science research*..

This research also makes use of the theory of systems thinking (N.J.T.A. Kramer & Smit, 1991). In the inaugural lecture of Maas (1991), it was suggested that the transformation model in construction would be a suitable way of looking at a design and production process. In this instance, a creative meeting is seen as a set of activities (a system) that maintains relationships with the surroundings (input and output) (Van Gerwen, 1974). The system can be managed and facilitated by using observations and design principles to make any necessary adjustments.

The design principles for this study were developed and validated during experiments and real cases in education and in professional practice in the AEC sector. The challenge of this practice-oriented research was to ensure the greatest possible methodical thoroughness and practical relevance (Andriessen et al., 2014). To guarantee the quality of the research, standards were set for the methodical thoroughness and the practical relevance.

The usability of the design principles was ensured by publishing the creative practices that were developed on the basis of the research, with publications in conference proceedings and on the Internet under the protected brand name Handstorm®.

In conducting this research, the researcher also played the role of a practical actor, such as an education developer, product developer, teacher, advisor, research manager, trainer et cetera.

The research process comprises a mix of a *knowledge flow* with a research cycle, with steps that contain the problem analysis, research method design, data collection, data analysis and reporting, and a *practical flow* that includes a regulatory cycle with the following steps: problem definition, diagnosis, plan, intervention and evaluation.

Based on the research problem and the chosen research approach, the objective of this research can be formulated as follows: *To improve creative and collaborative working during face-to-face design meetings in the AEC sector by developing a creativity facilitation course based on design principles.*

1.7. Summary and overview of the study

The field problem will be solved and existing scientific knowledge will be further developed according to the design science research approach by making a technological design and by documenting this study process. The technological design is a creativity facilitation course based on design principles.

The documentation of the technological design will be described in the following chapters. Chapter 2 will look at the research design that was created. Chapter 3 will report the first part of the research that identifies the parameters of collaborative working. Thereafter in Chapter 4, a creativity facilitation course based on a set of design principles will be presented and then validated in Chapter 5. Finally, Chapter 6 will present the conclusions with a reflection and discussion.

The Swalm river meanders through central Limburg, the Netherlands. Some artifacts we can design and build the way we want, but not all.

Chapter 2
Research design

2.1. Introduction

Chapter 1 formulated the following research objective: *To improve creative and collaborative working during face-to-face design meetings in the AEC sector by developing a creativity facilitation course based on design principles.* The field problem was identified as the research's point of departure.

Now, Chapter 2 outlines the research design, which involves choosing the research approach, ensuring the quality of the research and describing the research activities. Subsequently, the chapter discusses the formulation of the research topics and how research strategies (such as desk research, case study, experiment, and survey research) have been chosen to tackle these research topics. Finally, a plan for executing these research activities is presented.

2.2. Research approach

The research approach is *design science research*, which links practices with research findings (Romme & Endenburg, 2006) using *design principles* and *design solutions*. Figure 2.1 depicts this approach based on the *research-design-development cycle* adapted from Van Burg et al. (2008). The research-design-development cycle uses arrows to visualize knowledge and practice streams in design science research. The practice stream, flowing from right to left, develops new products or processes and provides practical experience. The knowledge stream, flowing from left to right, develops new scientific knowledge through the research activity *reflection-in-action* (Schön, 1987). These knowledge and practice streams continually repeat themselves with changing characteristics.

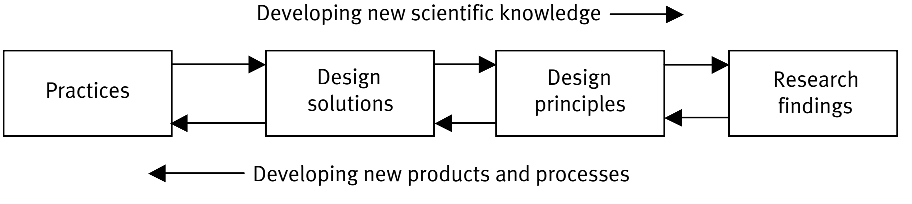


Figure 2.1. The research-design-development cycle (adapted from Van Burg et al., 2008).

2.3. Quality of research approach

The quality of the design science research approach has to be ensured so that the research is as methodologically thorough and practically relevant as possible (Andriessen et al., 2014). Methodological thoroughness means the results are reliable and valid, the reporting is transparent, the research design is explicit, and the conclusion is unambiguous, plausible and generic. A practically relevant design is one that is explicitly workable and useful, tested in practice, and the client finds innovative and valuable. To ensure methodological thoroughness and maximize practical relevance, the following three efforts will be made in this research to ensure its quality.

Validation

This study strives to validate the design principles in a pragmatic way. Therefore, the creativity facilitation course based on the design principles is evaluated in practice. This evaluation research is described by Swanborn (2007) (p. 11) as "research consisting of advice about the design, guidance during implementation and particularly, evaluation of the effects of an intervention in society". The results of the evaluation can be used to qualify the implementation of the set of design principles (Van Burg, 2011) (p. 154). This qualification can give an estimation of the validity of the set of design principles.

Some types of evaluation research are more effective than others. Veerman and Van Yperen (2008) have formulated a ladder that can help determine the effectiveness of interventions. This ladder is divided into four levels of explanatory power: (i) descriptive, (ii) theoretical, (iii) indicative, and (iv) causal. Our set of design principles will be evaluated for the first time in practice, in a complex, actual social environment and not in a laboratory. Thus, our evaluation will be conducted at the indicative level. This indicative evaluation research shows that the formulated goals are reached, the problems are decreased, the skills are enhanced, and the clients are satisfied.

The creativity facilitation course based on a set of design principles is considered a *technological design*, a "design that has been produced through the application of appropriate theoretical knowledge and methods" (Eindhoven University of Technology, 2014). The design principles derived from science and practice, and thereafter validated, can be considered applied theoretical knowledge and methods.

The course will not be evaluated according to the aspects functionality, construction, reliability, impact and presentation, which were proposed by Van Hee and Van Overveld (2012) as usual for a *technological design*. These aspects will not be used because it is more practical to initially have a generic set of design principles than to have only a specific design solution that is well devised. The course will therefore be evaluated on the learning outcomes of the course members.

Beta test

Some of the design principles were published early on in order to encourage scholars to experiment with them. The article entitled "Experiences with collaborative design by constructing metaphoric objects" by Van Gassel (2005) described not only the method of working with design principles but also presented questions of measuring the experiences with the method.

Method plausible rival explanations

To check the reliability of the results of the measurements, the method *plausible rival explanations* developed by Ropes (2010, 2011) will be used. This method first identifies plausible rivals and then explains how these rivals can be disqualified.

2.4. Research activities

The following research activities are required to achieve the research objective:

A. Developing a perspective by describing first how the various research sources are to be viewed. Verschuren and Doorewaard (1999) refer to this perspective as the assessment criteria. See Figure 2.2.

Then the other research activities must be operationalized by translating some steps in the research-design-development cycle into five research activities. A research activity is described using a rectangle to represent an activity and arrows are used to indicate the input and output of the knowledge and practice streams. These research activities are the following:

B. Developing a set of design principles by synthesizing research findings and experiences from practical experiments. See Figure 2.3.

C. Developing a course based on the set of design principles. See Figure 2.4.

D. Evaluating the course in practice. See Figure 2.5.

E. Qualifying the implementation of the set of design principles. See Figure 2.6.

F. Assessing the validity of the evaluation and qualification results. See Figure 2.7.

Figure 2.2. Developing a research perspective: research activity A

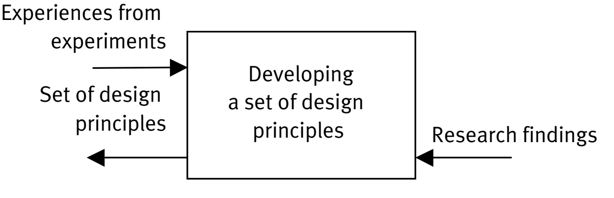


Figure 2.3. Developing a set of design principles: research activity B

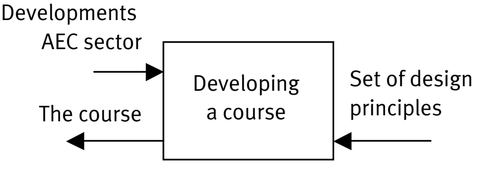


Figure 2.4. Developing a course based on a set of design principles: research activity C

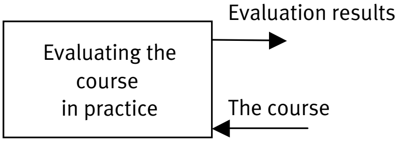


Figure 2.5. Evaluating the course in practice: research activity D.

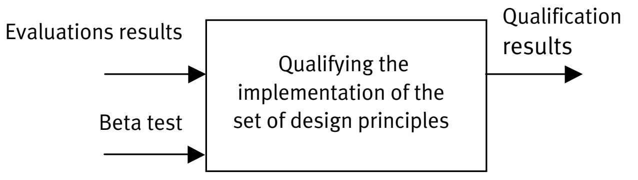


Figure 2.6. Qualifying the implementation of the set design principles: research activity E.

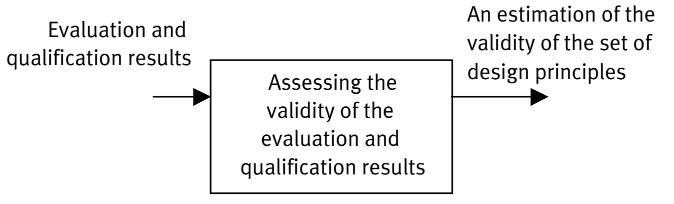


Figure 2.7. Assessing the validly of the evaluation and qualification results: research activity F.

2.5. Research topics and strategies

A research topic consists of a number of activities which are tackled using appropriate strategies. The central research topic is derived from the research objective and is formulated as follows: *Developing a creativity facilitation course based on validated design principles.* This central research topic is further divided into the following three main research topics:

1. *Finding parameters to describe collaborative working in design meetings*
2. *Developing the creativity facilitation course based on design principles*
3. *Validating the set of design principles*

These main research topics are handled as follows:

Main research topic 1, *finding parameters to describe collaborative working in design meetings,* is carried out by performing research activity A. The strategy is to study scientific and professional publications by carrying out desk research and conducting a case study.

Main research topic 2, *developing the creativity facilitation course based on design principles*, is tackled by developing a set of design principles by synthesizing conclusions from Ph.D. studies and from experiences achieved through published experiments (research activity B), and by using the set of design principles to develop the course (research activity C). The strategies are desk research and experiment.

Main research topic 3, *validating the set of design principles,* is tackled by evaluating the course in practice (research activity D), qualifying the implementation of the set of design principles (research activity E), and finally by assessing of the validity of the set of the design principles (research activity F). The strategies are experiment and survey research.

The detailed research approach and the results of the three main research topics are reported in Chapters 3, 4 and 5. Chapter 3, The conditions for successful automated collaboration, answers the research question of the first main research topic and is literally copied from the publication in the journal *Automation in Construction* entitled *The conditions* *for successful automated collaboration in construction (Van Gassel, Comneno, & Maas, 2014).*

In closing, Chapter 6 will provide the final results of the central research topic: *Developing a creativity facilitating course based on validated design principles,* consist of the creativity facilitation course, the set of design principles and some research methods. The course will be discussed on the extent it will solve the field problem. The set of design principles and the research methods will also be discussed on the aspects reliability, validity, generalizability, and contributions to the scientific domains. The limitations about the results will be mentioned, and suggestions for further research will be made. Finally, other results will briefly be mentioned.

2.6. Research structure

The planning of the research activities is visualized in Figure 2.8 by using a research structure, a format developed by Verschuren and Doorewaard (1999). This shows the research activities and topics to be tackled in order to realize the research objective.

For the main research topic 1 (Chapter 3), desk research and case studies were used to find assessment criteria in the theories of *building design management* and *small group creativity* to develop meeting parameters. For the main research topic 2 (Chapter 4), the meeting parameters found in the previous step served in turn as assessment criteria during the search for conclusions in research studies and articles about experiments. Synthesizing these conclusions enabled the development of a set of design principles that could be used to design, organize and run creative meetings, which are the basis for developing the creativity facilitation course.

For main research topic 3 (Chapter 5), the design principles were validated by evaluating the course in practice, by qualifying the implementation of the set of design principles, and at last by assessing the validity of the evaluation and qualification results. The results of the beta test will also be reported in this chapter.

The central research topic is addressed in the final chapter (Chapter 6), in which the final results are formulated and discussed.

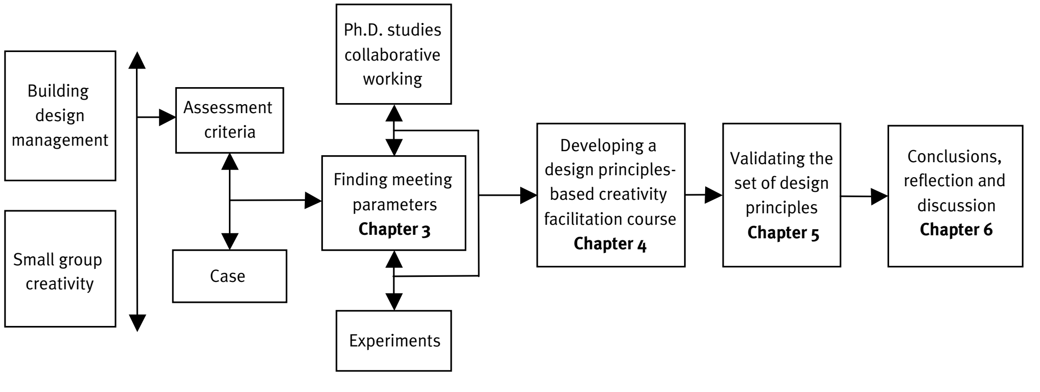
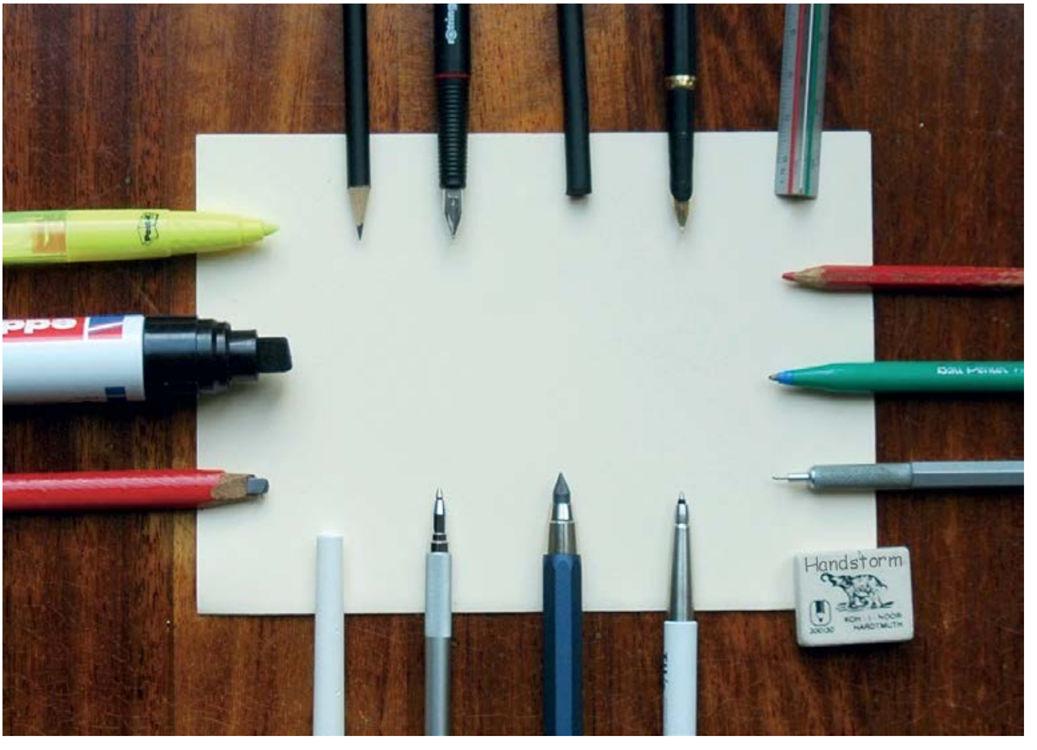


Figure 2.8. Research structure.



The character of the participants in a design meeting may be inferred from the type of writing tools they use.

Chapter 3
The conditions for successful automated collaboration in construction[3]

3.1. Introduction

A building assignment is a complex task that demands collaborative working in design meetings if added value is to be achieved for users and society (Van Eekelen, 2011). Wilkinson (2005) defined collaboration as: "A creative *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."

Meetings need to be successful, because:

- In the architecture, engineering and construction (AEC) industry a meeting is an important workplace where diverse professionals design on a collaborative way a public-private partnership (PPP) tender, a building object, or a production process.
- Added value for users and society must primarily be created in adequate prepared and facilitated meetings.
- High level value building information modeling (BIM) needs collaborative working environments (Grilo & Jardim-Goncalves, 2010).
- Participants in construction spend a substantial amount of their time in meetings (Rasberry & Lindsay, 1989; Watson, 2000).

Lousberg, Vande Putte, and De Jong (2010) described the goal of meetings thus: "to make transparent the drivers of the stakeholders to each other about their design proposals so that coordination and integration of project parts will be possible."

Emmitt and Gorse (2003) distinguished eight types of meetings during the design and construction process, namely client briefing meetings, design review meetings, design team meetings, pre-contract meetings, site-progress meetings, constructor team meetings, hand-over meetings, and feedback meetings. Emmitt and Ruikar (2013) also described facilitated workshops which are concerned with establishing and developing interpersonal relationships.

In this paper, the focus is on facilitated face-to-face design meetings in which professionals from different disciplines collaborate in "a closely coupled design process"

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[3] This chapter is integrally reproduced from an article in the journal *Automation in Construction* 39 (2014) 85-92 by F.J.M. van Gassel (Eindhoven University of Technology, the Netherlands), T. Láscaris-Comneno (Universidad Nacional de Costa Rica), and G.J. Maas (Eindhoven University of Technology, the Netherlands). The references have been changed into the APA style.

Kvan (2000). The participants make transparent their own design thinking, and listen with interest and respect to each other. They are willing to learn from each other, and understand that only in this way can a good and integrated result be achieved (Van Gassel et al., 2004).

Building information modeling (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. Grilo and Jardim-Goncalves (2010) distinguish five interaction types along the x-axis: communication, coordination, cooperation, collaboration and channel. Each type of interaction has along the y-axis three values levels: efficiency, differentiation, and value innovation. Collaboration is related with value innovation and described as 3D BIM & Collaborative working environment.

In a course on collaborative design on distance the first author (F.J.M. van Gassel) got the experiences that designers and design managers need special competences to collaborate in design and to organize distributed collaboration processes (Van Gassel et al., 2004). These competences have not only technology aspects but also "knowledge of the soft skills of information sharing and knowledge management, professional roles, and commercial context" (Pikas, 2013).

This knowledge will be obtained in this paper by studying face-to-face design meetings and should also be used by designing and using automated collaborative working environments.

The aim of the present study was to use desk research and case study research to identify variables that influence collaborative working in design meetings.

This paper systematizes an insight into meeting variables that stimulate collaborative work in design meetings, by answering the central question:

Which variables[4] describe collaborative working in design meetings?

A successful collaborative meeting needs not only a desired outcome but can also create an environment where participants and organizations can learn. A societal imbedding in a macro context of this last mentioned aspect of collaborative working is described in the following two sections.

3.2. Knowledge, learning, and economic development as context

The most advanced economies increasingly base their competitiveness on the generation and efficient utilization of knowledge for innovation. Increasing emphasis is being put on knowledge and knowledge transfer as development factors, as reflected in, for example, the World Development Report from 1998/99: "This World Development Report proposes that we look at the problems of development in a new way – from the perspective of knowledge" in (World Bank, 1998).

Kenneth Boulding, founding father of evolutionary economics, expressed it in the following way: "... as we have seen, all processes of production involve the direction of energy by some know-how structure toward the selection, transportation, and transformation of materials into the product". It is not "labor" that produces a commodity or product as Marx and indeed Adam Smith and Ricardo thought, but human knowledge and know-how,

[4] In the other chapters of this study the term 'parameters' has been used.

operating through institutions which enable this know-how to capture energy and rearrange materials" (Boulding, 1981).

Evolutionary economics implies that the dynamics of knowledge – that is, how knowledge is created, distributed, utilized, and destroyed – ought to be at the core of development theory. Achieving the interactions and synergies a country requires to advance toward an economy that is based on the production of knowledge-intensive goods and services, necessitates the inscription of this action in a society that presents high levels of structure and cohesion, and whose social capital offers the functional organization, coordination, and social integration capacities (Comneno, 2009).

Lopez and Johnson (2010) developed the idea that learning – in the broad sense of creating, distributing, and utilizing knowledge – is one of the driving forces behind social and economic change. They affirmed that knowledge has to be associated with learning, and learning with innovation, and posited that the term "a learning economy" is more adequate to characterize the current phase of socioeconomic development than "the knowledge-based economy". This is because all economies are based on knowledge, but not all economies are learning economies, since the term presupposes a certain speed of change in the knowledge base.

The concept of "learning economy" refers to an economy that is characterized by the ability to learn, internalize, and build on what is learned, so that new competences can be adapted or created. It is an economy where the rate of new knowledge and skill creation has increased, and also where the rate of obsolescence is evident, and thus the need for change has increased (Gregersen & Johnson, 2001).

A combination of technological developments, institutional change, and globalization has led to an acceleration of technical and economic change, a situation that presents firms with important and constant challenges in maintaining their competitiveness in their respective sectors.

An interesting development that tends to make learning more instrumental is the growing attention paid to "learning organizations" (Senge, 1990). The basic idea is that the way an organization is structured and the routines that are followed have a major effect on the rate of learning that takes place. The appropriate institutional structures may improve knowledge production in terms of competence building based on daily activities.

3.3. Consequences for the firm and its organization

We have entered a new era that is characterized by rapid change and the need to learn (and forget) rapidly in all economic activities. National economies and firms must therefore modify their organizational structure to fit and succeed in the new context.

The ability of firms and individuals to learn rapidly and acquire new competences as they are confronted with new types of problems, may be even more important for their economic success than their access to a given knowledge base. In the learning economy, new knowledge is being created at a rapid and probably increasing rate. At the same time, the quantity of relevant knowledge is being reduced, as knowledge becomes obsolete increasing quickly. This often implies "de-learning" old competences that could otherwise delay or block the development of new ones.

The way that work is organized in a firm can facilitate or hinder the transfer of knowledge and the learning processes within it. Innovation systems work through the introduction of knowledge into the economy (and into society at large), which requires active learning by individuals and organizations that are taking part in processes of innovation of different kinds.

Dainty, Moore, and Murray (2006) stated that a project manager can enable effective communication in the case of collaborative working. Meetings are a means to realize effective communication. The project manager must have an overview of the complete process that takes place, in order to attain an environment of functional flexibility. It is fundamental that he or she defines a global strategy that includes the organization of the various meetings and the establishment of their expected inputs and results.

It has been recognized that a good deal of learning occurs daily, during the actions that employees carry out and through the network of relations that are created within firms. However, it has also been recognized that learning depends on a person's level of commitment and the strengthening of trust. In turn, the latter depends largely on the communication channels between the different areas making up the structure of a firm, and the spaces for participation that are created to take advantage of what is learnt (Ruiz, 2007).

3.4. Method

The chosen research strategy was case study research and, to a lesser degree, desk and survey research. This is because a holistic rather than a reducible research approach was desirable, as a meeting is restricted in time and place (Verschuren, 2003; Verschuren & Doorewaard, 1999).

The research units were the meetings of the IFD Today research project – a demonstration project to experiment with the design and production of an apartment building system on the campus of Eindhoven University of Technology. A housing corporation had commissioned the design of an industrial, flexible, and demountable (IFD) building system for the existing stock of apartments. The existing apartments do not meet the current requirements for new buildings as set by the government and the occupants. To renovate the apartments would be too expensive.

IFD implies an integral approach to design and construction. In the design phase, all the involved professionals think deeply about what the consequences are for an industrial

Figure 3.1. Mockup of the IFD Today research project.

production, a flexible rebuilding, and a sustainable demolition of the structures, facades, installation, and finishing. See Figure 3.1.

The first author (F.J.M. van Gassel) participated in the IFD Today project and contributed his experiential knowledge to the design and production of the mockup and to the development of the IFD Today building system. He also participated in the project meetings, during which diverse professionals collaborated to design the building system and to design the production of the mock up. The meetings, which were held between October 1999 and February 2001, were the source of the data used to answer the central research question (*Which variables describe collaborative working in design meetings?*). This question was answered by answering four sub-questions:

1. *Which variables describe collaborative working in meetings?*
2. *Which variables describe the IFD Today meetings?*
3. *What are the values of these variables?*
4. *Which variables have a relationship with collaborative working in the IFD Today meetings?*

Systems thinking (Sterman, 2000) is a method to analyze meetings, because it is a "process of understanding how things influence one another within a whole."

In this research, we considered a meeting as a black box with an input and an output. We were interested not in the content of the box, but in the relationships between the input and the output (N.J.T.A. Kramer & Smit, 1991). See Figure 3.2.

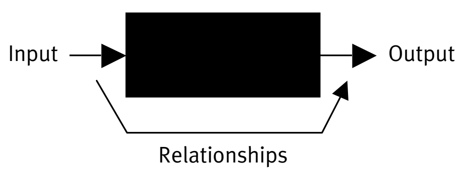


Figure 3.2. Modeling a meeting as a black box.

An exploratory study carried out by Van Gassel, Maas, and Van Bronswijk (2009) revealed that the Structured Analysis and Design Technique (SADT) can be used to describe the relationships (the SADT uses the word "entities") with the environment (Wikipedia, 2014).

The first sub-question (*Which variables describe collaborative working in meetings?*) was answered by:

- Selecting scientific articles appertaining to design and construction management in relevant scientific journals related to the first author's collaborative work in design research.
- Gathering the variables, rules, etc. given in the articles from the perspective of face-to-face meetings and collaborative design.

The second sub-question (*Which variables describe the IFD Today meetings?*) was answered by:

- Selecting relevant variables gathered in the first sub-question and by studying the IFD Today research project.

The third sub-question (*What are the values of these variables?*) was answered by:

- Developing a questionnaire based on the variables found in the second sub-question.
- Answering the questions in the questionnaire by studying the minutes of the IFD Today meetings.
- Recording the values of the variables in an MS Excel spreadsheet.
- Describing the values of the variables by drawing up statistics.

The fourth sub-question (*Which variables have a relationship with collaborative working in the IFD Today meetings?*) was answered by:

- Selecting variables based on the statistics of sub-question three.
- Grouping categories which are sharply distinguishable with each other by using statistical (pivot) tables and plots.
- Measuring relationships with the help IBM SPSS 20.
- Formulating null hypothesis and testing them with the help of IBM SPSS 20.

The questionnaire was completed only by the first author. A second round to validate the answers was not carried out, as only the first author participated in the project and in (90% of) the meetings.

3.5. Results

Sub-question 1: Which variables describe collaborative working in meetings?

To find relevant scientific articles a series of key words has been used. The key words were: meetings, group support systems, meeting processes, meeting outcomes, meeting effectiveness, group collaboration, support group work, design meetings, brainstorming, idea generation, design methods, team work, social interaction, face-to-face collaboration, collaborative creativity, creativity management, design management, value management, collaborative design, facilitation.

The articles were scanned on variables which describe collaborative working in meetings.

These variables are presented in Table 3.1 along with the relevant journal references.

Table 3.1. Variables describing collaborative working in meetings.

Variables	**Journal references**
Technology, socio attitudes, individuals' characteristics, meeting environments, meeting process attributes, meeting outcomes	Davinson (1997) p.165
Meeting design characteristics: agenda use, quality of facilitation, chairperson, punctuality, meeting size, attendee involvement. Attendees' perceptions of meeting effectiveness.	Leach, Rogelberg, Warr, and Burnfield (2009) p.76
Facilitation, room layout, group size, culture	Briggs and Vreede (1997) p.113
Effectiveness of design reviews Speech, textual, graphical, and gesture forms of communication	Ostergaard, Wetmore III, Divekar, Vitali, and Summers (2005) p.174
Design meeting activities: issue, alternative, criterion, project management, meeting management, summary, clarification, digression, goal, walkthrough	Olson, Olson, Carter, and Storrosten (1992) p.356
Communication acts according to Bales' IPA, successful/ unsuccessful group outcomes	Gorse (2002)
Brainstorming rules, social interaction rules	Matthews (2009) p.67
Social transactions: design values (form, material, aesthetic, uniqueness, purity, solutions), human values (spiritual, respect, jealousy, family, religion, mourning, comfort, tradition), requirements (activities, spatial, physical, review), narrative (direct support, indirect support, process detail, justification, tangent), process (communication, problem-solving)	Le Dantec and Do (2009) p.125
Communication among team members (who speaks and how much, what people say, how they say it and to whom, their roles)	Foley and Macmillan (2005) p.24
Activities for meeting support (preparing for meeting, keeping track of meeting flow, responding to needs in the moment, developing a summary of results, communicating results, maintaining team continuity and momentum between meetings), stages of conversation flows (establishing relationship, brainstorming, exploring possible plans, choosing an action plan, committing to results, resolving setbacks, acknowledging completions)	Bennet and Karat (1994) p.199
Facilitation (present or absent), recording method (flip chart or computer-aided recording), output (number of ideas)	T.J. Kramer, Fleming, and Mannis (2001) p.538
Model dimensions: type of communication, course of performance, working style, relationship between the nature of problems and the implications of solutions	Sonnenburg (2004)
Clustering between diverging and converging	Tassoul and Buijs (2007)
The workshop model: value development, different workshop agendas, team building	Hygum Thyssen (2011)

Sub-question 2: Which variables describe the IFD Today meetings?
A selection of variables that can be considered as inputs for and outputs of the black box (i.e., meeting activities) was made from Table 3.1 and IFD Today research documents. These are presented in Table 3.2.

Table 3.2. Selected variables in meetings.

Label variables	**Name variables**
Date of meeting	DMeeting
Plan	Plan
Quality of plan	ScenarioP
Location	Location
Aim of meeting	Aim
Type of meeting	MeetingT
Number of participants	ParticipantsN
Professionalism of participants	ParticipantsP
Type of extra participants invited	ParticipantsE
Control of meeting	Control
Meeting room	Meetingroom
Type of group working	Collaboration
Duration of meeting	DurationT
Blocks in meeting	DurationB
Special activities	Activities
Tools	Tools
Minutes	Outcome
Feedback	Feedback
Collaborative working	Actions

The names, labels, questions, and possible answers to the questions or categories are shown in the questionnaire presented in the Appendix B.

Sub-question 3: What are the values of these variables?
The values of 37 meetings were measured by means of the questionnaire. They were then entered into an MS Excel spreadsheet. The rows represent the meetings, and the columns represent the values of the variables.

An analysis of the values of the variables revealed the following:

- The 37 meetings were held over a period of 16 months.
- Plan: 12 of the meetings "had a plan;" of these plans, 11 were described "to a low degree" of precision.
- Location: 36 of the meetings were held in room at a "company location" or "university location."

- The "Aim of the meeting" scores on the sub-variables were as follows: "to learn competences" (1 meeting), "to develop vision & mission" (0) , "to develop strategies" (21) , "to create ideas & concepts" (2) , "to select solutions," (3) and "to control construction process" (10).
- Type of meeting: 14 were scheduled as "design group" meetings, and 8 as "construction group" meetings.
- The average number of participants was 7.32 (min. 5, max. 15).
- Expert as participant: an extra external "expert" was invited to only 5 of the meetings.
- Control of meeting: 2 meetings were chaired by "no specific person," 14 by a "facilitator," and 21 by a "participant."
- The meeting room for 34 of the meetings had a "traditional layout" (sitting round the table).
- Collaboration: the participants collaborated in a "plenary" way in 36 of the meetings.
- All the meetings had a maximum duration of "1 daily period." The unit of a "daily period" can be a morning or an afternoon.
- In only one meeting were special activities planned "to a considerable extent" in order to achieve a specific aim of the meeting.
- Tools: "no tools" were used in 3 meetings; they were used "to a small extent" in 29 meetings, to "a lesser extent" in 1 meeting, and to a "considerable extent" in 1 meeting.
- Outcomes: the "minutes" of 26 meetings were taken, and "detailed minutes" were taken of a further 10 meetings.
- Only after one meeting was there a "reflection" on the meeting activities.
- Collaborative working: actions in the meeting: mean = 2.00, Std. deviation = 2.58.
- Collaborative working: individual actions after the meeting: mean = 1.95, Std. deviation = 1.96.
- Collaborative working: Collaborative actions after the meeting: mean = 1.43, Std. deviation = 1.89.

Question 4: Which variables have a relationship with collaborative working in the IFD Today meetings?
Generated tables and plots shown that the variables "Aim of meeting," "Control of meeting," and "Tools" are powerful when their categories are grouped into two categories. Also collaborative working needed a grouping.

The grouping of the variables had been taken place on the following way:
- Aim of meeting was grouped into the categories "to develop strategies" and "to control construction process." The sub-variables "to develop vision & mission," "to create ideas & concepts," and "to select solutions" were added to "to develop strategy." The value "to learn competences" was left out. Rest N=36.
- Control of meeting was grouped into the categories "with facilitator" and "with no facilitator" (one of the participants was then chairing). Category "no specific person" was left out. Rest N=35.

- Tools was divided into the categories "no tools" and "tools to a small extent." Categories "good outcome", "very good outcome" and "not known" were left out. Rest N=34.
- Output was grouped into the categories "collaborative actions in the meeting," "actions/collaborative actions after the meeting," and "actions/collaborative actions in and after the meeting."

  The mean and median of the actions for the diverse categories are given in Table 3.3.

Table 3.3. The means and medians of the number of actions for the diverse categories.

Input		**Output**		
Variables	Categories	Collaborative actions *in* the meeting [Ao]	Actions/collaborative actions *after* the meeting [SumA1n]	Actions/collaborative actions *in and after* the meeting [SumA]
Aim N=36	To develop strategies N=26	Mean: 1.69 actions Median: 1.00 actions	Mean: 4.31 actions Median: 3.00 actions	Mean: 6.00 actions Median: 4.50 actions
	To control construction processes N=10	Mean: 1.70 actions Median: 1.00 actions	Mean: 1.30 actions Median: 1.00 actions	Mean: 3.00 actions Median: 3.00 actions
Control N=35	With facilitator N=14	Mean: 3.07 actions Median: 2.00 actions	Mean: 5.43 actions Median: 4.00 actions	Mean: 8.50 actions Median: 8.00 actions
	With no facilitator N=21	Mean: 1.24 actions Median: 1.00 actions	Mean: 1.95 actions Median: 2.00 actions	Mean: 3.19 actions Median: 3.00 actions
Tools N=34	No Tools N=5	Mean: 0.40 actions Median: 0.00 actions	Mean: 2.00 actions Median: 3.00 actions	Mean: 2.40 actions Median: 3.00 actions
	Tools to a small extent N=29	Mean: 2.15 actions Median: 2.00 actions	Mean: 3.72 actions Median: 3.00 actions	Mean: 6.17 actions Median: 4.00 actions

Set up null hypothesis (H_o) was necessary to verify that tests are derived from identical or nor-identical populations. The distributions of the input variables were considered as nonparametric. The nonparametric Mann-Whitney U test (also called the Wilcoxon test) was performed with the help of IBM SPSS 20 with significance (2 tailed) of 0.05.

In Table 3.4 the test results are given by calculation of the significance (Sig.) and by the conclusion that the null hypothesis (H_o) had to be retained or to be rejected.

Table 3.4. Results of the Mann-Whitney U test.

Input		Output		
Variable	Sub-variable	Collaborative actions *in* the meeting [Ao]	Actions/collaborative actions *after* the meeting [SumA1n]	Actions/collaborative actions *in and after* the meeting [SumA]
Aim	To develop strategies To control construction processes	Sig. 0.958 →Retain H_o	Sig. 0.002 →Reject H_o (A)	Sig. 0.037 →Reject H_o (B)
Control	With facilitator With no facilitator	Sig. 0.061 →Retain H_o	Sig. 0.018 →Reject H_o (C)	Sig. 0.001 →Reject H_o (D)
Tools	No tools Tools to a small extent	Sig. 0.038 →Reject H_o (E)	Sig. 0.448 →Retain H_o	Sig. 0.033 →Reject H_o (F)

The following null hypothesis (H_o) were rejected:

A. Meetings with the aim "to develop strategies" resulted in 332% more actions/collaborative actions *after* the meeting, than meetings with the aim "to control construction processes." N = 36; α = 0.002.

B. Meetings with the aim "to develop strategies" resulted in 200% more actions/collaborative actions *in and after* the meeting, than meetings with the aim "to control construction processes." N = 36; α = 0.037.

C. Meetings with a facilitator resulted in 278% more actions/collaborative actions *after* the meeting, than meetings in which one of the participants was the facilitator. N = 35; α = 0.018.

D. Meetings with a facilitator resulted in 266% more actions/collaborative actions *in and after* the meeting, than meetings in which one of the participants was the facilitator. N = 35; α = 0.001.

E. Meetings in which tools were used to a "small extent" resulted in 612% more actions/collaborative actions *in* the meeting, than when "no tools" were used. N = 34; α = 0.038.

F. Meetings in which tools were used to a "small extent" resulted in 257% more actions/collaborative actions *in and after* the meeting, than meetings in which "no tools" were used. N = 34; α = 0.033.

3.6. Discussion

The findings A to F in Table 3.4 show that the input variables of the meetings such as Aim, Control, and Tools have a relationship with collaborative work.

In the questionnaire, the "Professionalism of the participants" did not provide any distinguishing characteristics, as all the participants were "experts." However we did not find distinguishing characteristics, in literature we find that participants can influence collaborative work. Birkhofer and Jänsch (2003) stated that the acting and reacting activities of the designer can be performed in a wide range of languages, and can be disturbed by a specific barrier around the designer. Bucciarelli (2002) called this the "object world." Designers can have their own languages, tools, codes, unwritten rules, and scientific paradigms. It is therefore important to consider the characteristics of the participants in coming research.

In an earlier report written by the first author about experiences of the design and production of a building system during the IFD Today project, one of the conclusions was that "the design meetings must be organized" (Van Gassel, 2002a).

The Dutch government described the results of seven years of IFD building in the publication *Learning by Demonstration* (SEV, 2007). This study found that IFD building should make a leap from products to processes. The developing of these processes needs a design manager.

Governmental analyses of the critical success factors of IFD building concluded that the cooperation in IFD projects is difficult, and recommends initiating the interaction and facilitation between the actors (Van Gurchom, 2002).

Foley and Macmillan (2005) studied patterns of interaction in construction team meetings, and found that the type of interaction pattern has a relationship with the type of meeting (e.g., problem-solving, progress, or technical).

The new tendering procedures for complex building objects demand from the involved professionals a high level of collaboration with, and a high level of willingness to learn from, each other.

The variables such as Aim, Control, Tools (and also Participants) are worth further study in order to enhance collaborative working in design meetings. Figure 3.3 presents these variables in a scheme according to the SADT technique.

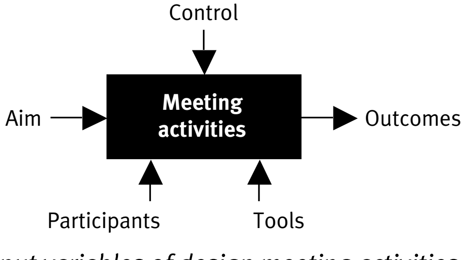


Figure 3.3. Input and output variables of design meeting activities.

3.7. Conclusion

The variables "Aim of meeting," "Control of meeting," "Participants," "Tools," and "Outcomes" is a suitable set to describe collaborative working in design meetings.

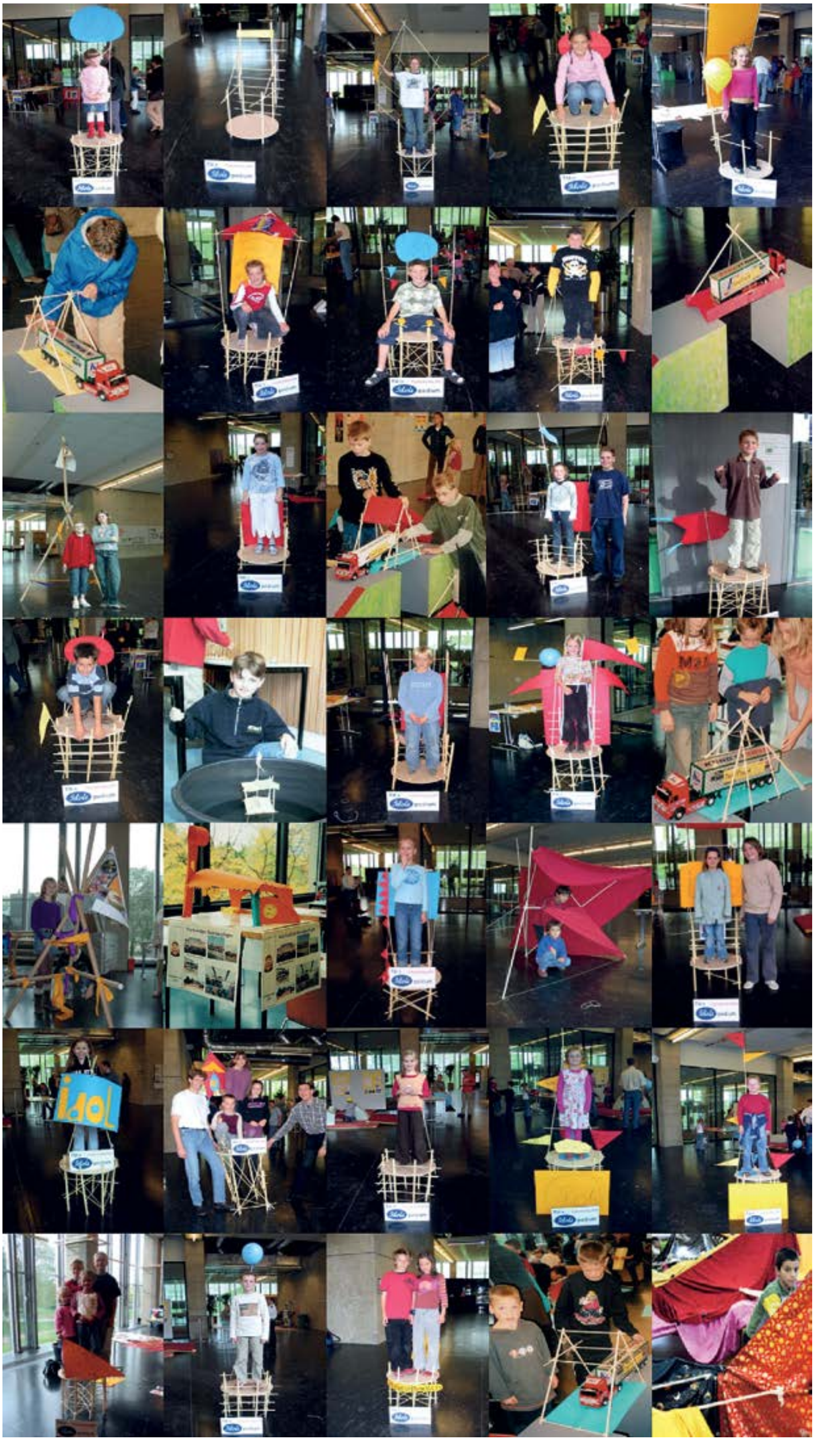
An important category of "Control of meeting" is a well chosen strategy of activities, such as (i) more penetrating the problem, (ii) (re)formulating the design question, (iii) finding answers on the design question and (iv) choosing the best solution for the problem. Each activity needs an effective tool and sometimes special invited participants. A tool for the activity (re)formulating the design is for instance "Challenge mapping" developed by Basadur (2002) and for the activity finding answers on the design question is for instance the design method Systematic Inventive Thinking (SIT) www.sitsite.com. Based on the "Aim of the meeting" (e.g., designing a vision or designing a production process) the meeting organizer can develop a suitable strategy based on validated relationships between the found variables in this paper.

Another important category of "Control of meeting" is the facilitation during the design meeting. This type of control is concerned with establishing and developing interpersonal relationships.

Our current direction of research is to use these variables to find validated relationships between the input and the output of design meetings. These relationships could assist in preparing and facilitating more successful collaborative meetings.

Acknowledgements

IFD Today was a partnership between Amnis housing corporation, contractor Heymans IBC, installer Stork, and Eindhoven University of Technology. The project was partly granted by the Dutch government. We would like to thank T. Paauwe for his comments.



The open days at Eindhoven University of Technology were a suitable opportunity for testing new teaching materials and enthusing young people to build something fun and exciting together.

Chapter 4
Developing a creativity facilitation course based on design principles[5]

4.1. Introduction

This chapter will explain the second main topic *developing the creativity facilitation course based on design principles*. According to the research design that was discussed in Chapter 2, this topic will be explained by first developing a set of design principles by synthesizing conclusions from Ph.D. studies and from the results of experiments in the AEC sector. After that, a creativity facilitation course will be developed based on this set of design principles.

First, we will identify the methods that can be used to develop design principles and a design solution, namely the creativity facilitation course. This will be followed by a discussion of specific practices in the AEC sector. This discussion will provide a context for the development processes. In the following sections, the methods that will be used to investigate the main topic and the sub-topics will be addressed. The results section will provide explanations of the sub-topics and the final section the author's reflections and conclusions regarding the second main topic.

4.2. Developing design principles

The set of design principles was developed based on the *research-design-development cycle* that was depicted in Chapter 2, Figure 2.1. Below, Figure 4.1 shows in greater detail how a design principle can be developed by synthesizing research findings and the results of experiments that were conducted during the researcher's professional work. The research findings are valid mechanisms that originated from scientific work on *building design management* and *small group creativity*. The results are the experimental interventions that proved to be successful.

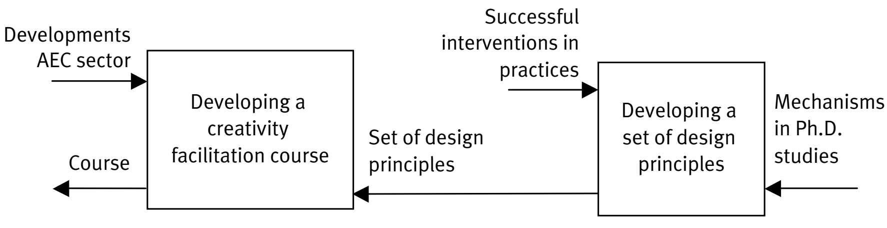


Figure 4.1. Developing a set of design principles and a creativity facilitation course.

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[5] The course design section of this chapter is based on a draft article for a scientific journal and was written in cooperation with Isabelle Reymen, Eindhoven University of Technology.

A design principle is formatted according to the CIMO logic: context, intervention, mechanism and outcome (Denyer et al., 2008).

4.3. Developing a creativity facilitation course

Figure 4.1 shows how a course generally can be developed. In this specific case the developing process uses the following terms: course main-aim divided up in sub-aims (long term), learning objectives (short term), didactic methods with corresponding tools, course program, learning outcomes, and course description. These terms are explained hereunder in more detail.

4.3.1. Course aims

In Chapter 1.3, the developments in the AEC sector are translated into a main-aim of a course, namely *to teach professionals to better plan, organize, and conduct face-to-face design meetings in the AEC sector*. The main-aim of the creativity facilitation course has been divided into six sub-aims. These sub-aims have already been outlined in Chapter 1.3. In order to make more clarity of the first five sub-aims, in the following list after each sub-aim its three key-values have been noted in parentheses between the round brackets: (i) *oriented to the AEC-sector* (responsibility, customer directed and letting go); (ii) *involved facilitation* (engagement, enterprising spirit and proactive); (iii) *stimulating cooperative learning* (empathy, eagerness to learn and synergy); (iv) *using varied skills and intelligences* (playfulness, imagination and inventiveness); and (v) *creating an open culture* (transparency, reflection and respect). The sixth sub-aim, *consulting the developed set of design principles*, can be incorporated by choosing a creativity facilitation course based on design principles.

4.3.2. Learning objectives

A learning objective can be defined as “a concrete description of the required knowledge that a student must acquire and use, or the desired behavior that a student should be able to demonstrate, after completion of the course or the lesson” (Erasmus University, 2013). To deeply integrate the design principles into the creativity facilitation course, the learning objectives will be derived from the design principles.

4.3.3. Didactic methods and corresponding tools

Learning objectives can be operationalized when they are supported with didactic methods and corresponding tools (J.W.M. Kessels & Smit, 2007). To select the appropriate didactic methods to achieve the learning objectives, the taxonomy of Bloom (1956) is useful. Krathwohl (2002) revised the Bloom taxonomy of cognitive processes and developed the following taxonomy ranging from lower order thinking skills to higher order thinking skills: remember, understand, apply, analyze, evaluate and create. The last thinking skill is the highest level; it involves putting the elements together to form a coherent or functional whole or reorganizing elements into new patterns or structures through generating, planning or producing. Lower order thinking skills are necessary to learn higher order thinking skills.

In the literature, specific skills have been formulated to facilitate design meetings. Kolb and Rothwell (2002) concluded that small-group facilitators serve two functions of the group: (i) they explain the task and relate it to the job that needs to be done and (ii) they maintain the group dynamics by paying attention to the psychological needs of the group and the relationships between the group members. Moreover, they stated that "stimulating group insights and creativity" (p. 201) competence is specifically important for neophyte (creative) facilitators. In a study that examined design meetings, Rollof (2009) explained that "a good meeting leader should understand the mechanisms and processes operating in meetings".

4.3.4. Course program and description

A list of didactic methods and tools to use during certain time slots forms the course program. A leaflet which recruits participants for the creativity facilitation course based on design principles contains the following information: title, main-aim, sub-aims, the set of design principles, what you learn, for whom the course is intended, themes, didactic methods, trainer qualifications, and study load. In practice a participation fee will also be addressed.

4.3.5. Learning outcomes

The course can be evaluated by measuring what the participants have learned. What do they remember from the theory of creative thinking, how have the creative (leadership) behavior been changed, and what did they with the learned skills in practice? These learning outcomes have to be described in such a way that they can reliably be measured. During the development of the course information and insight are needed regarding the special wishes of the course provider, characteristics of the potential course members working in the AEC sector, appropriateness of didactic approaches for this target group, and the availability of suitable tools to measure learning outcomes.

4.4. Practices in the AEC sector

The meeting design principles were developed in part based on interventions in the AEC sector that proved to be successful. During his career in the industry and at a university, the researcher of this study designed, implemented and evaluated some building products, construction processes, construction systems and learning processes in the AEC sector. An important and recurrent theme of these experiences was the importance of developing a concept or idea as a group in a methodical way.

These practical experiences that focused on industrial construction and construction management and engineering are evaluated and briefly discussed with references to some key publications in the two following subsections.

4.4.1. Industrial construction

In this context, industrial construction includes the following concepts: modular building, mechanization & robotization at the construction site, and industrial, flexible and demountable (IFD) building.

Modular building is the assembly of modular construction elements in the factory, which are subsequently transported by road to the building site, where they are assembled into a modular building. Modular construction elements and buildings consist of a grid of specific dimensions. The connections between the modular construction elements consist of quick-couple, dry-point and line connections. A modular construction element that can still be transported by road is called a module (Van Gassel, 2006).

Mechanization is the application of work force by means of a tool instead of a worker; with robotization, thinking tasks are also executed using a tool or robot (Van Gassel & Maas, 2008).

IFD building is a concept devised by Hermans and Damen (1997). The publication *Learning by showing* [Leren door demonstreren] (SEV, 2007) evaluated 92 building projects that had been subsidized by the government. The researcher of this study participated in one of the projects, called IFD TODAY. The IFD building concept can be described as a three-pronged strategy to innovate the building process: the client (flexible), the manufacturer (industrial) and society (demountable) (Van Gassel, 2003).

4.4.2. Construction management and engineering

Educational experience gained while teaching at Eindhoven University of Technology (TU/e) has been combined with research for this study. Teaching was based on tutorials, lectures, projects and graduation projects that were developed, held and supervised as part of the scientific groups for Uitvoeringstechniek [Construction Technology], Construction Management and Engineering (CME) and Performance Engineering for Built Environments (PEBE). The subjects of study included transport at building sites, mechanization and robotization at building sites (Van Gassel, 1999a), designing construction production processes (Van Gassel & Roders, 2006), collaborative creative thinking, collaborative design (Van Gassel et al., 2004) and gerontechnology (Van Gassel & Van Bronswijk, 2010). Developing a course entails carefully formulating learning objectives, and selecting or developing and continually optimizing the appropriate didactic methods and tools to be used. The development of the didactic methods was not limited to the usual tutorials, but included the development of educational games, graduation workshops, international study visits, etc. Also working methods for the professional practice of project/process management in the AEC sector were developed. These methods included a training course to teach designing, organizing and conducting creative design meetings in tender processes.

4.5. Method

The introduction to this chapter identified the main topic, namely *Developing the creativity facilitation course based on design principles.* This main topic consists of the following four sub-topics:

1. *Finding mechanisms that enhance collaborative working in a literature review of Ph.D. 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 strategies used to find and develop the four sub-topics will be outlined below.

4.5.1. Finding mechanisms

- When conducting the various experiments and reporting the ecperiences (as referred to in sub-topic 2), some Ph.D. studies were consulted.
- Collaborative working in design meetings can be described using the following set of parameters: 'Aim', 'Control', 'Participants', 'Tools' and 'Outcomes' of the meeting, as mentioned in Chapter 3 and depicted in Figure 3.3. These parameters are the criteria to select the mechanisms in the Ph.D. studies.
- Ph.D. studies were used because the results are based on extensive research or are a combination of multiple studies. Supervisors and reviewers are qualified scientists. The results of a Ph.D. study are published in scientific journals. If there was a reason to do so, these journals were also used as sources.
- The description of a Ph.D. study comprises the following elements: title, abstract/citation, reference and selected mechanism.
- The mechanism is described as a short assertion. To create such a small unit of publishable information, the assertion contains the concepts: *Subject – Predicate – Object* (Nanopub.org, 2011).

4.5.2. Finding successful interventions

- During the past 20 years of giving lectures, performing (contract) research and organizing symposiums, the researcher has conceived and conducted a number of experiments.
- These experiments have been documented in reports, product descriptions, questionnaires and publications. Several were published in conference proceedings and professional journals. Other external parties also wrote about the experiments and the methods as well as the results. These sources have been used to describe a successful intervention. An intervention can be considered successful if it has resulted in an example of creative or collaborative working in the broadest sense of the word.
- The syntax of the description of a successful intervention should include the desired result.
- In this study, the experiments have been documented according to the case study method of Hutjens and Van Buuren (2007). The following questions have been answered based on working documents such as announcements, applications, and invitations: Who were the actors? What were the activities? Where did the activities take place? When did the activities take place? What objects were involved?

4.5.3. Developing the design principles

- Executing the syntheses of the mechanisms and the successful interventions is a long-term, iterative process of conducting experiments that are based on evaluations from previous experiments (WHAT) and the research findings (WHY).
- A design principle must meets the CIMO logic: in a situation (Context), use (Intervention) because (Mechanism) in order to come to an (Outcome) (Denyer et al., 2008).
- In Table 4.1, the development of a design principle is described. The WHAT column shows one or more of the relevant successful interventions found in the research in

sub-topic 2, and the WHY column shows one of the more relevant mechanisms found in research in sub-topic 1. The final column depicts the newly developed design principle with the following CIMO logic: in a situation (C) use (I) that leads to (O) because (M). This order of words differs from the syntax from Denyer et al. (2008) because this is a more fluid way to describe design principles.

- Table 4.2 presents an example of how a design principle can be developed to organize a garden party that can be held regardless of weather conditions.
- A brief commentary will also be given for each design principle.

Table 4.1. The development of a design principle.

Successful interventions		**Mechanisms**		
WHAT	**+**	**WHY**	→	**Design principle**
Successful intervention Si1 Successful intervention Si2 Syntax: Intervention **results in** a desired result		Mechanism M1 Mechanism M2 Syntax: Subject – **predicate** – object		Design principle DP1 Syntax: In a situation (C) use (I) that leads to (O) because (M)

Table 4.2. An example of how a design principle can be developed to help organize a garden party that can be held regardless of weather conditions.

Successful interventions	**Mechanisms**	**Design principle**
Si1 Use an umbrella to **protect** yourself from the rain. Si2 With a wind screen the wind loads are **transferred** by guy-ropes and tent pins to the ground.	M1 Shoring the structure **ensures** diffusion of wind forces. M2 A waterproof canvas **repels** rain drops.	DP1 At a garden party (C) use an anchored and waterproof party tent (I) because this construction prevents problems with wind and rain (M) in order to keep the guests dry and safe (O).

4.5.4. Developing the course based on design principles

Prior to starting the development of the course, the following prerequisites must be considered: the participants should have a degree from a university or a university of applied sciences, primarily in technical sciences. Moreover, they must be working in the AEC sector and they should have had a number of years of experience as a director, manager, supervisor and/or engineer. The course will be given by two trainers: one with a background in construction management & engineering that included creative and collaborative working, and the other with a background in group dynamics and personal development. Prior to the course, individual interviews will be conducted to obtain insight into the level of skills and motivation of the course participants. These interviews will be repeated after the course has been completed to determine the degree to which the information and skills learned have been embedded in the participants' professional environment. The interviews will also help them reflect on their participation experience. The maximum number of course participants will be 10, and the study load is approximately 35 hours.

The development of the creativity facilitation course program progressed through the following steps:

1. The learning objectives will be derived from the design principles. For example, for the design principle "During a meeting (C) a break (I) is necessary to keep the participants energized (O) because some exercises give participants energy (M)", a learning objective should be formulated as follows: "At the end of the course, the participants know the appropriate moment to start a suitable energizer". The didactic method could be to give examples of energizers and to conduct one during a training meeting. The first words of a learning objective could be "At the end of the course, the participants know/can ......"
2. The appropriate didactic methods and accompanying tools need to be chosen for the course program. To select or devise didactic methods, we took into account the course sub-aims, listed in Chapter 4.3, and the learning objectives derived in the previous step. We also had to take into account the different characteristics of individual course participants because they originate from different disciplines in the AEC sector (Bax & Trum, 1992) and they tend to use their own "object world" languages (Bucciarelli, 2002). In addition, differences in types of intelligence were accounted for when choosing the didactic method. For example, we used the following categorization of intelligences based on the senses: the auditory type (hearing listening), the haptic/ locomotive type (feeling, doing, experiencing, experimenting), the reading type (written text), the visual type (seeing, images, demonstration), the discussion type (verbal interaction, discussion), and the writing type (making notes and transcribing) (Hoogeveen & Winkels, 2011). Finally, the participants can also have *different learning styles*. Kolb *(*Simons, 2012) distinguished between the following styles: dreaming (e.g., reflecting, designing); thinking (e.g., analyzing, abstract thinking); daring (e.g., experiencing, feeling) and doing (e.g., experimenting). To select the didactic methods, all of the following phases of Kolb's learning cycle should be applied: concrete experience, observation and reflection, analyzing and abstract thinking, and experimenting. This allows participants to discover a skill they are good at and which they can develop further. This approach is also known as experiential learning (Laevers, 2000).
3. The course will be outlined in the format of a leaflet to recruit participants.
4. To evaluate what the course members have learned, learning outcomes will be described.

4.6. Results

4.6.1. Finding mechanisms

The mechanisms were found in 28 Ph.D. studies. In Table 4.3 the left column lists the relevant research for each Ph.D. study, giving the title, a citation and/or brief description, and the reference. The right column lists the selected mechanisms.

Table 4.3. Descriptions of Ph.D. studies and the selected mechanisms.

Descriptions of Ph.D. studies	**Selected mechanisms**
P1 **Managing collaborative design** "This research concludes that in collaborative design, the design process is very much a social process. Designing is a social process that requires trust, sharing of ideas, negotiations, trade-offs, and consensus to bring efforts into coherence. While advances in construction engineering and project management may offer solutions to many technical problems, the social complexity in collaborative design has yet to be assessed properly and dealt with by design management." (Sebastian, 2007) (p.148)	**M1** Considering designing as a social process brings efforts into coherence.
P2 **Understanding collaborative design** An influencing factor for creating shared understanding is on the actor level: "the equality of the language used between the actors." (Kleinsmann, 2006) (p.281)	**M2** Using common terminology creates shared understanding.
P3 **On problem solving in a technical domain** "When giving instructions (.....), the emphasis should be on the process of solving the problem and not on whether or not the final solution is correct." (Vaags, 1975) (p.194)	**M3** Instructions promote the problem-solving process.
P4 **Describing design** **A comparison of paradigms** Reflecting on design activities can help to frame a design task and solve the design problem in an experimental fashion. (Dorst, 1997) (p.211)	**M4** Reflection promotes progression of the process.

Descriptions of Ph.D. studies	Selected mechanisms
P5 **How the group affects the mind** This study suggests two ways to enhance group idea generation. First, it is advisable not to express ideas out loud, but to share them in some other way. Other people's ideas must be available when they are needed; i.e. when an individual can no longer come up with new ideas on their own. Second, the group can be divided into pairs. There are a number of advantages to working in pairs; less time is spent waiting for each other, there is access to other people's (stimulating) ideas and it fosters a relatively high level of perseverance. (Nijstad, 2000) (pp.156-157)	**M5.1** Pairs produce ideas more efficiently. **M5.2** Visibly recording ideas promotes their availability to all participants.
P6 **From quantity to quality** "In sum, these studies support the notion that deeper exploration of available knowledge can increase the originality of the ideas that people generate. Furthermore, a priming exploration, which increases the accessibility of specific domain knowledge, can induce such deeper exploration without changing the nature of the brainstorming task. However, the effects of deep exploration apparently do not carry over to idea selection." (Eric Fulco Rietzschel, 2005) (p.117)	**M6** Exploring the problem enhances the quality of ideas.
P7 **Styles of architectural designing:** **Empirical research on working styles and personality dispositions** A conclusion of this study is "that students prefer to work with a partner having the same product style, whereas they are indifferent with respect to the process style of their partner. It was also concluded that a student's process style preference is independent of that student's product style preferences". (Van Bakel, 1995) (p.249)	**M7** The personality traits of participants determine the working style.

Descriptions of Ph.D. studies	Selected mechanisms
P8 **Creating while learning** “The concept of the diversity of design strategies (linked to Van Bakel’s six design strategies) is also specified in more detail by applying Kolb’s learning cycle. The four different approaches to experiential learning: experiment – experience – reflect – theorize are used to enhance the diversity of the available knowledge and activities when doing exercises that support design”. (Proveniers, 2005) (p.158)	**M8** Experiential learning stimulates the idea of creating while learning.
P9 **Sketching in design idea generation meetings** “The different characteristics of the graphic and sentential processes suggest that they serve different purposes as design methods. Sentential idea generation may better serve the traditional role of creative problem solving techniques in design methodology, which is to generate a large number and variety of design ideas, of which some can be selected to further develop into design solutions. Graphic techniques may be more suitable when, instead of a large of number of ideas, a smaller but more refined collection of novel design ideas are desired”. Guidelines to support graphic idea generation: “Build on each other’s ideas; interpret ideas constructively; strive for ideational fluency and look for wild connections, especially when interpreting your own ideas.” (Van de Lugt, 2001) (pp.197-198)	**M9** Graphic techniques enhance the quality of ideas.
P10 **Improving design processes through structured reflection; A domain-independent approach** “The complete design method consists of five steps for each design session, namely planning a design session, defining the subtask of the design session, reflecting at the beginning of a design session, designing during the core of a design session, and reflecting at the end of a design session.” (Reymen, 2001) (p.158)	**M10** A design session consists of a schedule that defines the subtask and three reflections (before, during and end).

Descriptions of Ph.D. studies	Selected mechanisms
P11 **Effective interpersonal communication and group interaction during construction management and design team meetings** "Successful teams use more emotional interaction, occasionally showing extreme emotional expression, such as showing solidarity, being friendly and showing anger and tension." (Gorse, 2002) (p.213)	**M11** Successful teams use emotional expressions.
P12 **Playing, leadership and team development in innovative teams** "To lead an innovative team is a paradoxical challenge for a leader. On the one hand, the team needs time to create and to destroy, needs freedom to take risks, and freedom to break with procedures and rules without being punished. On the other hand, at the same time a team must work efficiently toward a goal within the constraints established by organisational resources and culture. These paradoxical elements have to be somehow "managed" by the leader." This means that proper group dynamics in the team is a precondition for performing these two opposing tasks. (Hohn, 1999) (p.204)	**M12** Creating space and taking charge fosters the desired performances.
P13 **The psychology of creativity: moods, minds, and motives** "Creativity can be achieved through flexible, global, and divergent thinking and through systematic and persistent probing of a few categories and ideas". (Baas, 2010) (p.179)	**M13** Creativity can be achieved through flexible, global, and divergent thinking.
P14 **Facilitating team cognition** "Interact. The core mechanism of team cognition is that individuals interrelate their activities to those of others, as a result of interactions. Consequently, they can envision the system they are part of. This is not different for designers: Interact with other team members and objects. Designers need to see and experience what others are doing, by interacting with them directly, discuss, negotiate, work together, sketch. And they need to see and experience the artifacts of what others did." (Stompff, 2012) (p.305)	**M14** Designers need to see and experience what others are doing.

Descriptions of Ph.D. studies	Selected mechanisms
P15 **The reflective practice in product design teams** This study is based on the principle that designing is considered a "reflective way of working" based on Donald Schon's theory of the "reflective practice". To describe the design activities, a descriptive model has been developed that comprises the following design activities: *naming, framing, moving and reflecting*. In this process, a project manager can play the roles of "frame coach", "reflection guard" and "move helper". (Valkenburg, 2000) (p.72)	**M15** "Designers work by *naming* the relevant factors in the design situation, *framing* this situation in a certain way, making (experimental) *moves* toward a solution and *reflecting* on these moves".
P16 **Collaborative design support;** **Workshops to stimulate interaction and knowledge exchange between practitioners** The Collaborative Design Workshop facilitates a methodical introduction for knowledge exchange between the two practitioners in the conceptual phase of roof design. "The use of the Morphological Overview as Design Support Tool which was loose introduced in a design task in the Definitive Collaboration Design Workshop" did achieve the aim of him research. (Quanjel, 2013) (p.215)	**M16** Workshops stimulate interaction and knowledge exchange between practitioners.
P17 **Learning to innovate;** **A series of studies to explore and enable learning in innovation practices** "The results revealed that the prescriptive value of the design principles[6] is limited. The design process is not as systematic as simply defining a difficult situation, choosing a design principle, designing an intervention, and implementing the intervention in practice. Six factors were identified that influence the phases of the design process: rational analysis, previous experiences, ability, affinity, creativity and ambition." (Verdonschot, 2009) (p.239)	**M17** Creativity and previous experiences are factors that influence the design of interventions.

[6] The definition of the use of design principles here differs from Denyer.

Descriptions of Ph.D. studies	Selected mechanisms
P18 **Coping with complexity in integrated water management** A design meeting could be considered a "complex adaptive system" on a micro scale. "... these do not aim for maximum order and chaos. Too much order and too much chaos can both result in a loss of adaptive power of the system. Actors perform interventions in a system by applying structure to it: new rules, standards, constructions, etc. If this creates too much order, the resulting tension will be released in the form of a crisis. During the crisis, the system flips from a situation with a lot of order to a situation with a lot of chaos. It becomes unstable within a short period of time. However, the system will subsequently recover. Crises are characteristic of healthy complex adaptive systems. Crises are crucial for the timing of interventions." (Geldof, 2002) (p.167)	**M18** A crisis might restore a process.
P19 **Rules for disorder;** **Lessons from the history of contrary design** Eggink (2011) identified five different contrary design steps. These five steps have two traits in common: "Functionality is not the same as usefulness" and placing an object in a different "context" to learn a different way of looking at things. (Eggink, 2011) (p.287)	**M19** Placing the object in a different context teaches participants to look at things in a different way.
P20 **How to measure added value of Corporate Real Estate (CRE) and building design;** **Knowledge sharing in research buildings** This study looks at a number of causal mechanisms that play a role in designing workplaces/buildings for knowledge workers. One of the key mechanisms is: "Visibility triggers awareness of what other employees are doing and whether one can provide help. Outcome: increased interaction and collaboration". (Meulenbroek, 2014) (p.148)	**M20** Face-to-face working leads to increased interaction and collaboration.

Descriptions of Ph.D. studies	Selected mechanisms
P21 **Knowledge at work, a study of the means for knowledge management in construction companies** “The purpose of this study is to develop instruments for making it possible to manage knowledge in construction companies.” The model provides a categorization system to organize the different types of knowledge in a company. This can be considered a problem-solving system. When managing knowledge, “employees are not just asked what they know, but are asked what they know within a context of a problem-solving system.” (Schaefer, 1991) (p.134)	**M21** Derive empirical knowledge in the context of an objective to be able to share it.
P22 **Facilitating value creation and delivery in construction projects; New vistas for design management** This study delivered a Vector model of Influences on Value creation (VIV model) and “aims to illustrate the complexity of influences on the development of partial solutions in a ‘collaborative’ design process”. The influences are disciplines, theory, habit, rhetoric, information, power and media. The study also developed a workshop approach. A conclusion of the research is that “design is an ongoing conversation that includes elements of learning and negotiation, which is affected by the people who participate in local discussions (and the professions in which they work)”. (Hygum Thyssen, 2011) (p.391)	**M22** Mechanisms used to stimulate learning and negotiation are necessary to handle social processes in local group interaction.
P23 **Developing construction products not linked to projects** This doctoral research is about such topics as product development and marketing in the Netherlands, encouraging and limiting factors, and factors of success and failure in product development processes. One conclusion is that “collaborative projects are much less likely to succeed than individual projects”. There are some reasons for this: deficient balancing about importance, different effort (time and money), clashing cultures, and personalities. (Lichtenberg, 2002) (p.244)	**M23** Facilitating development processes with more knowledge of human dynamics enhance working together.

Descriptions of Ph.D. studies	Selected mechanisms
P24 **Integral design method in the context of sustainable building design;** **Closing the gap between design theory and practice** One of the objectives of this study was to develop a method that could integrate engineering design knowledge into the design process during the conceptual design phase. "All of the teams managed to exploit the morphological design tools to successfully include knowledge from the individual's disciplines" (Savanović, 2009) (p.109)	**M24** Creating a morphological schematic for integrated engineering design combines knowledge.
P25 **Creating traces, sharing insight;** **Explorations in embodied cognition design** Thinking not only takes place in the mind, but also in interaction with the environment, which consists of other people and physical objects. This interaction can also be organized during creative sessions. In that case, the challenge is to design the proper techniques to prompt this interaction. The researchers developed and tested the NOOT and FLOOR-IT tools. These tools, as well as the use of sticky notes and other such devices "are both the outcome of people's earlier actions, as well guiding further actions" and "social artifacts, created in and for a social context, publicly available and socially accountable". (Van Dijk, 2013) (p.246)	**M25.1** Interactive meeting tools stimulate embodied cognition. **M25.2** Interactive meeting tools make user values visible.

Descriptions of Ph.D. studies	**Selected mechanisms**
P26 **The designer's inner strength;** **The role of intuition in the design process** This study clarifies the role of intuition in the design process. In-depth interviews with the designers have highlighted the fact that rationale and intuition play a role in the design process. In the literature, rational thinking has been "given an (undeserved) main role." The study shows that the development of the designer, of intuition and of the design process has a synthesizing effect on one another. By using all levels of their consciousness, designers are capable of bringing complex design problems to a favorable conclusion. (Groeneveld, 2006) (p. 348 and 351)	**M26.1** Learning how to use intuition consciously ensures that designers know who they are and understand their own way of designing. **M26.2** By using all levels of their consciousness, designers are capable of bringing complex design problems to a favorable conclusion.
P27 **The effects of thinking in silence on creativity and innovation** The proposition studied was "that suspending the group (temporarily) can be productive for innovation, when at least one group member has relatively low extraversion". De Vet concluded that, "under certain conditions, thinking in silence can positively affect individual and group creativity and can affect the type of innovation ideas selected by a decision making group". (De Vet, 2007) (pp. 81 and 83)	**M27** Thinking in silence by designers has a greater positive effect on individual creativity.

Descriptions of Ph.D. studies	Selected mechanisms
P28 **Working both ways;** **The interplay of trust and interaction in collaborations** This thesis shows that over time, trust dynamics are reflected not only in the content and atmosphere of conversations (with characteristics such as openness) but also in the process of holding conversations on a micro level. “It provides support for the proposition that an increase in trust results in observable (and measurable) changes in the interaction process. It also describes the kind of interaction dynamics that can take place in a high-trust situation as episodes of interaction flow and that are desirable for their often creative and innovative outcomes as well as for their positive effect on trust. Through these contributions, this thesis will reduce the intangibility of trust in collaborations and makes trust dynamics more visible”. (Van Oortmerssen, 2013) (p.97)	**M28** Increase in trust results in changes in the interaction process.

4.6.2. Finding successful interventions

The successful interventions were found in 14 experiments that have been examined for this study. The experiments are described in Tables 4.4 through 4.18. Each table includes a description of the relevant research experiment, as well as the relevant interventions that are described in publications and mentioned in the column ‘sources’. An intervention can be considered successful if it has had the desired outcomes within a context of creative and collaborative working.

Table 4.4. Experiment E1.

E1

Product development DE MEEUW OIRSCHOT BV

Between 1980 and 1991, the researcher of this study worked as a product developer for De Meeuw Oirschot BV. This company designed the MAX60 modular construction system and the related production facilities. The design team comprised internal and external architects, industrial designers, structural engineers, building physicists, installers, maintenance consultants, users, sales people, and craftsmen. The team did a great deal of experimenting with construction elements and buildings, both in the factory and on site. The clients of this modular accommodation were closely involved in the process. Figure 4.2 below depicts the assembly of the first prototype of the MAX60 building on the campus of Eindhoven University of Technology.
"As a result of its in-house development, De Meeuw has entered into a collaboration with an architect and an industrial designer" ("Symposium Booosting by De Meeuw Oirschot on 23th November 1989," 1990). Figure 4.3 shows the final version and the introduction of the MAX60 modular construction system.

Figure 4.2. Assembly of the prototype of the MAX60 semi-permanent modular construction system on the campus of Eindhoven University of Technology in 1987. This building is still in use even in 2016!

Figure 4.3. Left picture, the final design of the MAX60 in1988 in Markelo and the middle picture in Breendonk, Belgium. Right picture shows also a frame turned placed as stairway

Successful interventions	**Sources**
Si1.1 Use close collaboration between professionals while designing a construction project in order to create added value for the user. (Van Gassel, 1991)	Van Gassel, F.J.M. (1991). Kant-en-klaar bouwproduct verandert rol architect [Ready-made building product changes the 'role of the architect]. *BouwWereld, 87,* p. 10-11.
Si1.2 For a design team to create an innovative modular construction system, use the support of external designers and consultants. (Mulder, 1991)	Mulder, A. (1991). Mobiel kantoor: de upgrading van het noodlokaal [Mobile office: the upgrading of the temporary school building]. *Intermediair, 27*(45).
Si1.3 Design principles applied to the development of modular construction systems are also useful for designing permanent buildings. (Van Gassel, 1996)	Van Gassel, F.J.M. (1996). *Mechanization and automation by the manufacturing of removable modular buildings.* Paper presented at the Proceedings of the 13th ISARC, Tokyo, Japan.
Si1.4 For involve users in designing Dutch (modular) buildings, use a Japanese approach. **(**Van Gassel & Van Blokland, 1996)	Van Gassel, F.J.M., & Van Blokland, A. (1996). Modulair bouwen in Japan [Modular building in Japan]. *Technieuws, 34*(7), p. 15-18.

Table 4.5. Experiment E2.

E2

Product development GE Capital Modular Space in Uden, the Netherlands

Affiliated with the Department of the Built Environment of Eindhoven University of Technology (TU/e), the Stichting Universitair Centrum voor Bouwproductie (UCB) [The University Center for Building Production Foundation], supported a product development process to create a movable accommodation construction system for GE Capital Modular Space in 1994 and 1995. The UCB was represented by Ger Maas and Frans van Gassel.
For the development of the MOBI unit construction system, a project organization was established that comprised the following process elements: program of requirements, steering group, working parties, group meetings, meeting records, working formats, a manual and a development matrix. On one axis of this matrix is the product and process design, on the other axis is the development and specification of concepts, construction, testing and assessing the prototype and scaling up to serial production. Consultants shared their knowledge of and experience with supporting structures, roof-top structures, mechanical engineering and electrical systems.
See Figure 4.4 for an accommodation in practice.

Figure 4.4. MOBI unit construction system according to the product data sheet

Successful interventions	Sources
Si2.1 Decisions about the development of the construction system should be made by a steering group, enabling realization of the prerequisites that had been formulated. (*Samenwerkingsovereenkomst tussen UCB en GE Capital Modular Space*, 1994)	Cooperation agreement between UCB and GE Capital Modular Space. Eindhoven, 1994.
Si2.2 Designing the structural nodes yourself results in a flexible and standardized construction system. (Van der Stap & Van Gassel, 1994)	Van der Stap, M., & Van Gassel, F.J.M. (1994). *Literature study of structural nodes.*
Si2.3 Doing structured exercises during brainstorming sessions teaches participants how to design together. (Verstegen, 1994)	Records of brainstorming session 27, September 1994. Drawn up by Ad Verstegen from Mobiel Units under number NOT P04

Table 4.6. Experiment E3.

E3

Product development De Groot Vroomshoop BV

Affiliated with the Department of the Built Environment of Eindhoven University of Technology (TU/e), the Stichting Universitair Centrum voor Bouwproductie (UCB) supported a product development process for a movable accommodation construction system for De Groot Vroomshoop from 1997 through 1999. The UCB was represented by Ger Maas and Frans van Gassel.

For the development of a sustainable, flexible and market-oriented UCB unit construction system, a project organization was established that comprised the following process tools: program of requirements, steering group, (sub) working groups for sales, technology and production, schedules, records, future scenarios, well-defined assignments for working groups, push pull points (KOOP), product-market combinations, poster presentations, a construction system manual, construction prototypes, etc.

External companies shared their knowledge of and experience with supporting structures, concrete elements supply industry, dimensions, and H & E systems. See Figure 4.5 for photographs that were taken on site during construction.

Figure 4.5. The modular UCB construction system under construction and the right is finished

Successful interventions	Sources
Si3.1 Meetings of steering group with the working groups encourage the development of a shared vision. (*Organisatie ontwikkeling Permanent bouwsysteem (PBS): projectdocument*, 1997)	Organization of the development of a Permanent Building System (PBS): project document. (1997) *UCB-*
Si3.2 The use of control documents such as a clarification of the design and production process, the push pull points [klantorderontkoppelingspunt], product-market matrix, cost allocation sheet, and De Groot Life Cycle encourage joint development. (De Groot Vroomshoop, 1999)	De Groot Vroomshoop (1999). *UCB construction system manual.*

Table 4.7. Experiment E4.

E4
Research study Stichting Bouwresearch (SBR) [Building Research Foundation]
The researcher for this study conducted a previous study entitled “Uitvoeringsgericht ontwerpen” [construction friendly design] on behalf of the Stichting Bouwresearch (SBR) in 2001 and 2002. The SBR described the problem by stating; “The knowledge of construction is not or not sufficiently communicated with the designer and also poorly timed. The two parties do not understand each other, even though they do meet”. Based on a study of the literature and a poll among construction experts, followed by a final meeting, prerequisites for a guideline on working together were developed.

Successful interventions	Sources
Si4.1 Plenary meetings of steering groups and working parties encourage the development of a shared vision. Si4.2 Specifications used by a process manager to organize and run design meetings are important for collaboration, because professionals can learn from each another. (Van Gassel, 2002b)	Van Gassel, F.J.M. (2002b). Uitvoeringsgericht ontwerpen [*Construction friendly design*]. Eindhoven: Stichting Universitair Centrum voor Bouwproductie (UCB) TU/e.

Table 4.8. Experiment E5

E5
Product development IFD Today
In the period from 2001 through 2003, the Department of the Built Environment of Eindhoven University of Technology, in a joint venture with the construction industry and a housing corporation, designed and built an industrial, flexible and demountable (IFD) apartment block on the university campus. The researcher for this study was a member of the research group. Three elements played a role in this design: a vibration-free floor, sustainable design, and a flexible system for sewage, heating, electrical and water.
See also Figure 4.6 and Chapter 3 of this study.

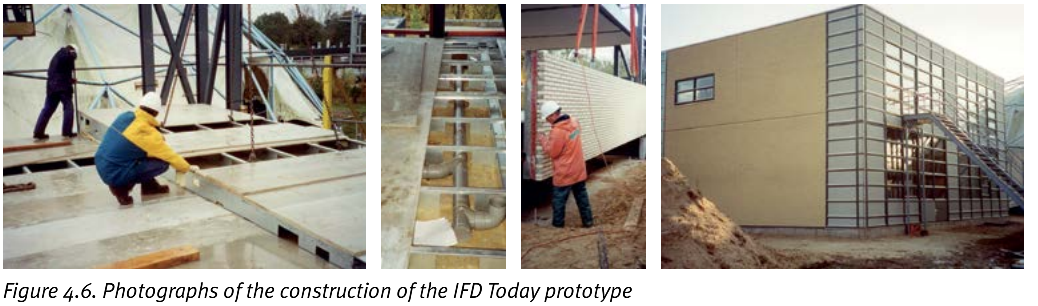

Figure 4.6. Photographs of the construction of the IFD Today prototype

Successful interventions	Sources
Si5.1 In IFD building, the design process requires co-operation and a multidisciplinary approach. Matters such as design tasks, choice of designers, design tools and expected results must be considered during the course of the design process and design meetings must be organized. (Van Gassel, 2002a)	Van Gassel, F.J.M. (2002a). *Experiences with the design and production of an industrial, flexible and demountable (IFD) building system.* Paper presented at the 19th International Symposium on Automation and Robotics in Construction (ISARC), Gaithersburg, Maryland, USA.

Table 4.9. Experiment E6.

E6
IFD Buildings tool development
In 2004, the PRC Bouwcentrum participated in the European research project on IFD Buildings. The "Production design feedback model" sub-assignment was executed by the Stichting Universitair Centrum voor Bouwproductie (UCB). UCB created a design tool to design a production process for a modular construction system and communicate the result with the architectural designers.
See Figure 4.7 for a production scheme.

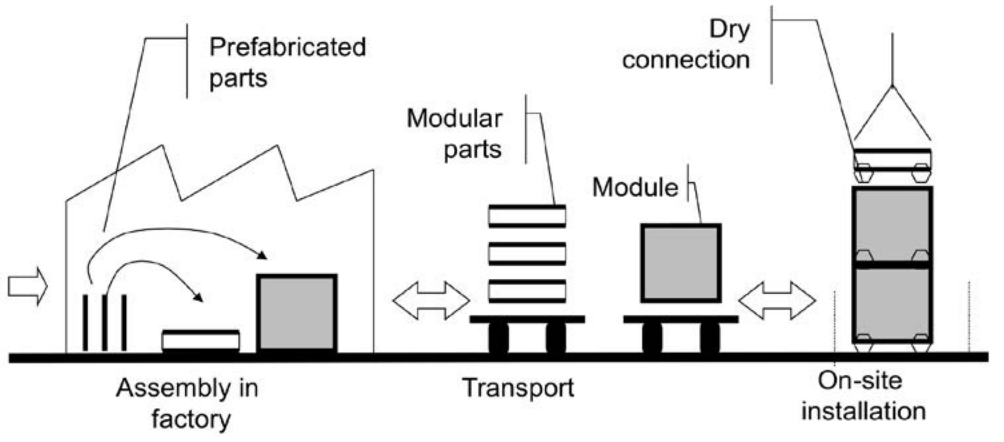

Figure 4.7. Modular construction system production scheme

Successful interventions	Sources
Si6.1 A design tool stimulates the interaction between designers in a team. (Van Gassel & Roders, 2004) (Van Gassel & Roders, 2006)	Frans van Gassel, Martin Roders, 2004, IFD Buildings. Production Design Feedback Model. UCB report. Van Gassel, F.J.M. and M. Roders (2006) *A Modular Construction System. How to design its production process?* In: F. Scheublin (Editor) Proceedings of the Joint CIB, Tensinet, IASS International Conference on Adaptability in Design and Construction. Volume 3. Eindhoven. pp. 12.1 – 12.6.

Table 4.10. Experiment E7.

E7

Courses in user-oriented design method

For the TU/e lectures on "Arbeid en materieel" [Mechanization on the construction site] (1993-2005) and "Robotics and home automation" (2008-2010), an analysis and design method was developed that invited a group of students to observe and analyze problematic situations in practice. This was subsequently used as the basis for the design and for detailing improvements. See Figure 4.8 for an improvement.

Figure 4.8. Example of a solution for keeping stability. Handrail with an extra moveable bar.

Successful interventions	Sources
Si7.1 Continued use of an agreed upon analysis and design method supports designers in solving the problems of users (together). (Van Gassel & Maas, 2008) (Van Gassel, 1999a) (Van Gassel & Van Bronswijk, 2010)	Van Gassel, F.J.M. and G.J. Maas (2008) *Mechanising, Robotising and Automating Construction Processes.* In: Robotics and Automation in Construction. Ed: Carlos Balaguer and Mohammed Abderrahim. In-Tech. F.J.M. van Gassel, 1999, Mechanization on the construction site (in Dutch), Chapter 5: Methodical design worker machine system, Eindhoven University of Technology lecture notes. F.J.M. van Gassel, J.E.M.H. van Bronswijk, 2010, Working method to enhance end-user value for aging-in-place. Proceedings ISARC2010, Bratislava, Slovakia, pp. 627-633

Table 4.11. Experiment E8.

E8

Course on creativity and innovation in design teams

From 2004 to 2013, an annual workshop entitled “Creativity and innovation in design teams” was organized for Master’s and post-graduate students.

The course description of the workshop stated the following about the context of the module: The party commissioning a structure requires sustainable and robust architectural solutions for their business processes. Only a solution jointly developed by designers, such as architects, urban planners, structural engineers, building physicists, installation consultants, property consultants, construction process designers, etc., can meet this requirement.

The process of joint development is not automatic, but must be planned and managed. This lecture develops participants’ skills in this area.

The learning objectives of the workshop are:

- To increase knowledge of creative thinking
- To gain insight into the use of creativity techniques
- To gain insight into planning and controlling architectural design meetings

The training format was comprised of a brief explanation of theory, group exercises and reflection on the exercises. See Figure 4.9 that shows students at work.

Before and after the workshop in 2012, the students answered some of the 17 questions about facilitating a design meeting. The answers were placed on a four-point Likert scale. Among the nine participants, a significant improvement was measured in terms of four questions:

- Do I change the position of the tables and chairs in the meeting room? (Sig 0.051)
- Do I use special formats during the meeting? (Sig 0.017)
- Do I immediately assess the feasibility of the participants’ solution? (Sig 0.003)
- Do we laugh when a participant makes a mistake? (Sig 0.035)

Figure 4.9. Students at work during the workshop.

Successful interventions	Sources
Si8.1 Students should discover that they can still be creative (together) when applying specific methods. Si8.2 Postponing judgment during a design meeting is a skill that can be acquired. Si8.3 Change the position of the tables and chairs in the room where the design meeting is held. Si8.4 Use special forms of design during the design meeting.	Evaluation reports written by the students. Poll among students who participated in the workshop in 2012.

Table 4.12. Experiment E9.

E9

Collaborative design course

Starting in 2003, a workshop called Collaborative Design for Master's and post-graduate students has been given. The responsible lecturer was Jos van Leeuwen and later Bauke de Vries. See Figure 4.10, where students are at work. The experiences gained from the course that spanned a number of years have been recorded in a conference paper. An abstract of this paper is presented below.

Abstract:
"In conceptual design of architectural artefacts, designers from different disciplines work together. Multi-disciplinary collaboration is required when buildings and their construction have a complex nature. If this collaboration is not effective and efficient, it might lead to the construction of buildings that clients disapprove cost too much regarding the delivered quality and extend the throughput time as well as raise failure cost. Collaboration in design takes place in physical spaces, as well as in distributed, or virtual environments. Virtual design teams use a range of ICT tools to support both synchronous and asynchronous communication. While these tools are designed to facilitate collaboration, the collaboration process still requires planning and organisation, which is an activity that students and professionals need to learn. In current practice there is a need for designers and design managers with competences to collaborate in design and to organise distributed collaboration processes.
Keywords: Construction Management, Collaborative Design, ICT Tools, Experiential Learning."

Figure 4.10. Class collaborative design.

Successful intervention	Sources
Si9.1 Experiential learning is a method that can be used to learn how to organize the collaborative processes. (Van Gassel et al., 2004)	Frans van Gassel, Jos van Leeuwen and Ad den Otter (2004) *Experiences with a course on collaborative design on distance.* Proceedings ISARC2004, Jeju Island, Korea. Editors: Moon-Young Cho, Sang-Rok Oh and Young-Jo Cho From page 310, 6 pages, Paper/ CD Rom

Table 4.13. Experiment E10.

E10
Constructing a platform
A modular platform has been developed for various training purposes. See Figure 4.11. The experiences with this platform have been described in a conference paper. An abstract from this paper is quoted below:
"A building assignment is a complex task that demands collaborative working in order to achieve added value for users and society through creative construction management. Modular building systems are used in workshops in the building environment domain to make students aware of various phenomena that occur in the process of creative construction. Existing modular building systems used in training do not include the experience of failure as a motivator for creative construction. This article validates an innovative set of modular building materials (Handstorm®) that have a high innate risk of construction failure, as a tool in using failure as a motivator in creative construction. It reports on the effect of both innate failures; such as instability or collapsing and emotional failures, such as the success of a competitor or losing a competition. The results indicate that the presence of failure stress is a valid motivator in teaching creative construction
Management" (Van Gassel et al., 2013).

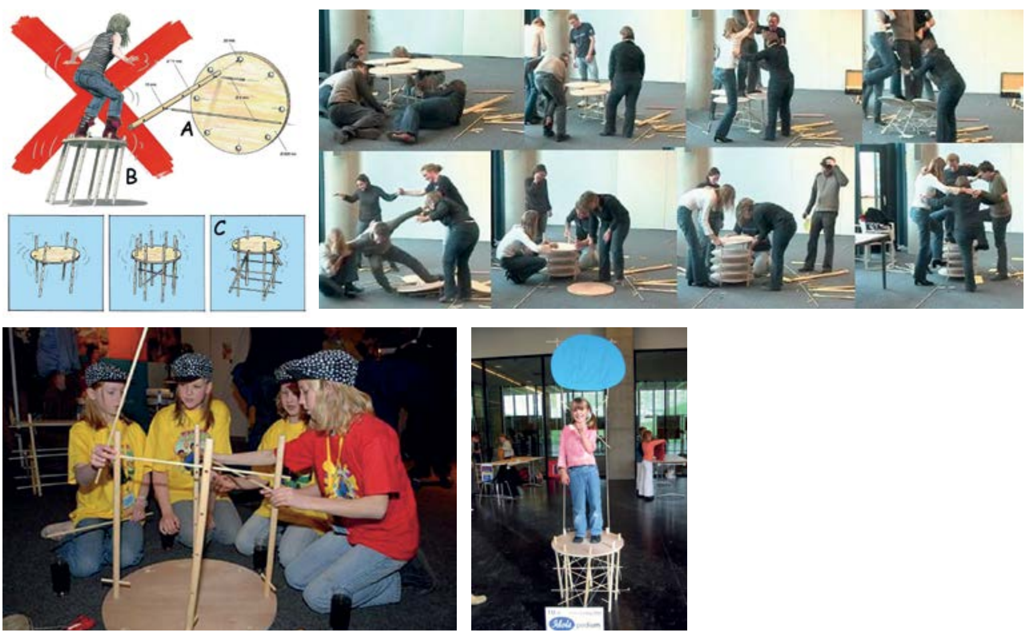

Figure 4.11. Modular platform

Successful interventions	Sources
Si10.1 Failure stress is a valid motivator in teaching creative construction management. (Van Gassel, Visser, & Van Bronswijk, 2013)	Gassel, F.J.M. van, Visser, M.J.E. & Bronswijk, J.E.M.H. van (2013). *Failure stress as a motivator for creative construction management.* In M. Haidu & M. Skibniewski (Eds.), *Proceedings of the Creative Construction Conference 2013 (CC2013), 6-7 July 2013, Budapest, Hungary*, (*pp. 242-253*). Budapest

Table 4.14. Experiment E11.

E11

Constructing metaphoric objects

The author of this study developed a creativity technique that can be performed in a group. The technique entails making an object using your hands. The parts of the object are artifacts from which it is difficult to directly derive a meaning, as opposed to models or pieces of LEGO®. See Figure 4.12 in which participants are creating a metaphoric object during design meetings.

Figure 4.12. Constructing metaphoric objects.

Successful interventions	**Sources**
Si11.1 A drawing, collage or construction needs a story to give it significance. Si11.2 Spoken text must be retained in some other way, e.g. by writing it down. (Van Gassel, 2005) (Van Gassel, 2004)	Gassel, F.J.M. van (2005). *Experiences with collaborative design by constructing metaphoric objects.* In H.H. Achten, K. Dorst, P.J. Stappers & B. Vries, de (Eds.), *Proceedings of the Symposium Design Research in the Netherlands 2005, 19-20 May 2005, Eindhoven University of Technology, The Netherlands*, (*Bouwstenen, 92, pp. 63-70*). Eindhoven: Eindhoven University of Technology Gassel, F.J.M. van (2004). *Handstormen. Leren in Ontwikkeling*, *16*(June), 16-16
Si11.3 When implementing a working method with which the participants are not familiar, the working method should be introduced using an example. (Van Gassel & Maas, 2005)	Van Gassel, Frans and Ger Maas (2005) *The development of a human-centered work method for design meetings.* Proceedings of the CIB W096 meeting, November 2005, Copenhagen, Denmark. Editor Stephen Emmitt.

Table 4.15. Experiment E12.

E12
Partner selection simulation game
In new tendering formats, companies are looking for partners to work with. How do they select these partners and what should be taken into account? A training session in the form of a simulation game has been developed to answer these questions. The game was played in six parallel sessions during the Value Development in Construction Management (VDCM) symposium in 2006.
During the session, two groups were formed that were either going to climb a mountain or travel to a desert island to relax. The learning objective of the training session was to make participants aware of how a selection process works. Do I choose or am I chosen?

Figure 4.13. Stage of the partner selection simulation game.

After the training session, all of the participants were asked to evaluate their experience. One of the participants noted that; “I think that the game simulation is a good way to find out what partner selection is all about”.
Using a five-point scale ranging from “Do not agree” to “Agree”, the average score from 98 participants was 3.4.
Participants were also asked to consider the selection criteria on a four-point scale ranging from “Not important” to “Very important”. The selection criteria “Trust”, “Reliability” and “Cooperation” scored higher than the other, more objective criteria, N = 105.
The participants were professionals from the business community and government, and Construction Management and Engineering students.

Successful interventions	**Sources**
Si12.1 A simulation game is an amusing working method to become aware of which (social) aspects are relevant for working in groups. (Van Gassel & Favie, 2006) Si12.2 Making independent choices is based on emotions. (Abdalla, 2006)	Van Gassel, F.J.M., & Favie, R. (2006). Partner selection simulation game instruction *UCB report*. Eindhoven: UCB. Abdalla, G. (2006). *Partner selection; an objective and subjective comparison: study into a decision-theory model for an objective and subjective comparison of partners.* (Master’s thesis), TU Eindhoven, Eindhoven.

Table 4.16. Experiment E13.

E13
Creative Supply and Demand game
The fourth symposium for Value Development in Construction Management (VDCM) from the study association Of CoUrsE! on the theme of “Creative Supply and Demand” was held in 2007.
While traditional specifications always formed the basis of collaboration between parties on the supply and demand side, partners in the construction process have discovered the advantage of having a more open attitude towards the other party. This change has also impacted the tasks on the demand and supply sides. The demand or request must be formulated as a challenge, so that parties on the supply side, the tender providers, are invited to come up with different versions. Tenders are not only assessed in terms of price, but also on quality, ingenuity and on whether the underlying question is answered.
The symposium presented an educational game in the morning and lectures in the afternoon. A role play during the educational game highlighted how a client, in this case a municipal council, uses design criteria to determine their selection criteria and make their dreams clear to the tenderers. The tenderer’s challenge was to find out what the municipal council wanted by asking the appropriate questions. In other words; what is the question behind the question?
The educational game was developed by the Master’s degree program Construction Management and Engineering (CME) in collaboration with Suzanne Verdonschot van Kessels & Smit, and was played simultaneously in eight different locations. The game was hosted by CME professors and students who had been specially trained for this. Immediately after the game, the participants (N = 74, number of participants about 100) were asked a number of questions, which were answered as follows:

- I learned some things during the game:
  Yes (21); More or less yes (44) Neutral (4); More or less No (5) and No (0)
- I will use what I have learned in practice:
  Yes (17); More or less yes (36) Neutral (14); More or less No (4) and No (0). Missing (3)
- I liked learning things about “Creative Supply and Demand” by means of an educational game:
  Yes (37); More or less yes (32) Neutral (3); More or less No (2) and No (0).

Several weeks after the symposium, 99 participants were asked what they had learned during the symposium. Learned a lot (19), Learned some things (72), Didn’t learn much (8).
During the educational game, participants could draw inspiration from design principles written on cards. Thirteen of the 18 participants indicated that; “the design principles on the cards helped explain what we find important in a plan”.




Figure 4.14. Participants at work during the educational game and the final discussion.

Successful interventions	Sources
Si13.1 A simulation game is an educational method that can be used to teach and then implement what was learned. Si13.2 A simulation game teaches participants how to think creatively. Si13.3 Supplying ready-made statements (e.g. design principles) during development of a plan works. (“Symposium VDCM2007: “Creatief vragen en aanbieden”,” 2007)	Keursten, P, Verdonschot, S, Kessels J, Van Rooij, M. 2007. Design principles for knowledge productivity. Syllabus Symposium VDCM2007. TU/e. VDCM2007 Symposium “Creatief vragen en aanbieden” Bouwpers 10, edition 23, 4th July 2007. Publications of the TU/e Department of the Built Environment. Poll among participants immediately after the game Poll among participants several weeks after the game.

Table 4.17. Experiment E14.

E14
Workshop *Bouwen Aan Mogelijkheden* 'BAM Kracht'
In 2007 and 2008, the construction company BAM Group developed a workshop that sought to enhance the brainpower of professionals in tendering procedures by consciously looking at things differently and thinking in terms of opportunities. To this end, the thinking model 'BAM Kracht', building on opportunities, was developed, a WYBERT**+** comprising four phases: (re)formulating the question, creating space, focusing, and drawing up an action plan. See Figure 4.15.

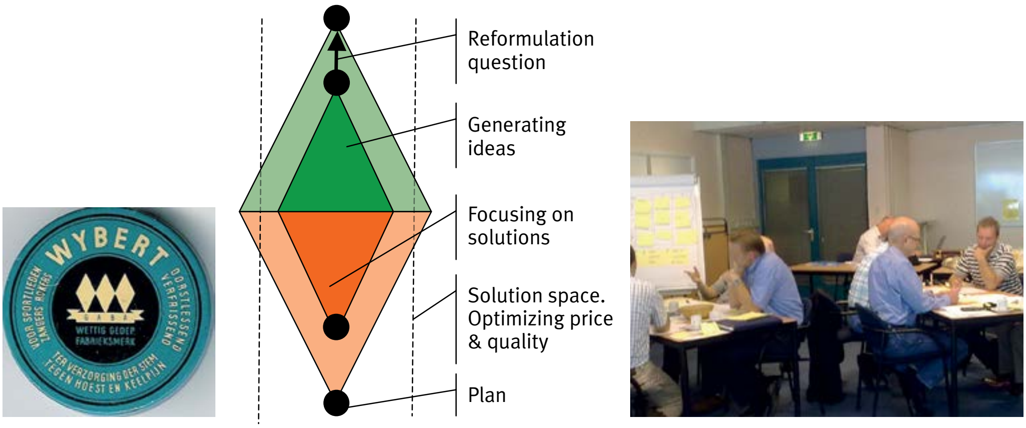

Figure 4.15. WYBERT+ "Building on opportunities" thinking model.

During the workshop, the concept of creative thinking and how creativity techniques work were explained, and exercises were done. About 6 four-hour sessions were held. The initiator of the workshops, Peter Lapidaire from BAM Civiel asked 63 participants seven evaluation questions; 40 participants answered the questions. Lapidaire concluded from the answers that the workshop was useful and that more BAM employees should attend it. All participants saw the positive effect of applying creative thinking during the tendering process.
On the basis of these workshops, the BAM Business School developed the training program "More creative thinking in tendering teams".

Successful interventions	Sources
Si14.1 Creative thinking is a useful skill for employees in a tendering process. (Lapidaire, 2008) Si14.2 The Wybert**+** model provides structure for the activities necessary for a design meeting.	Peter Lapidaire, email dated 29th October 2008, Feedback on Workshop BAM Kracht.

4.6.3. Developing the design principles

The design principles were developed by synthesizing the selected mechanisms and the successful interventions. Table 4.18 presents the results of this reasoning process. The process of creating the design principles is not the outcome of a single activity, but of an iterative reasoning process. Two important parts of this process are studying scientific publications and conducting and evaluating relevant experiments.

Table 4.18. Design principles that were developed from successful interventions and mechanisms.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
1	Si4.2 Specifications used by a process manager to organize and run design meetings are important for collaboration, because professionals can learn from each another. Si5.1 In IFD building, the design process requires cooperation and a multidisciplinary approach. Matters such as design tasks, choice of designers, design tools and expected results must be considered during the course of the design process and design meetings must be organized.	M10 A design session **consists** of a schedule that defines the subtask and three reflections (before, during and end). M15 Designers **work** by *naming* the relevant factors in the design situation, *framing* this situation in a certain way, making (experimental) *moves* toward a solution and *reflecting* on these moves. M21 **Derive** empirical knowledge in the context of an objective to be able to share it.	Develop a scenario for a design meeting in advance by making an appropriate choice from one of the following parameters: aim, participants, tools and control. This leads to a situation in which the facilitator can anticipate a wide variety of situations which help to achieve the desired outcome. This is because from the start, design activities need a well-thought out *name* and *framework*.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
2	Si1.1 Use close collaboration between professionals while designing a construction project in order to create added value for the user. Si1.2 For a design team to create an innovative modular construction system, use the support of external designers and consultants. Si1.4 For involve users in designing Dutch (modular) buildings, use a Japanese approach.	M2 Using common terminology **creates** shared understanding. M7 The personality traits of participants **determine** the working style.	Ensure that there are a variety of personalities, team roles and skills among the participants of the design meeting. This leads to a wealth of knowledge and a multitude of ideas that can be shared. This occurs because multiple talents stimulate each other.
3	Si8.1 Students should discover that they can still be creative (together) when applying specific methods. Si11.3 When implementing a working method with which the participants are not familiar, the working method should be introduced using an example.	M3 Instructions **encourage** the problem-solving process.	Use or develop the creative skills of the meeting participants by beginning with a brief creativity exercise using a common or familiar design. This leads to the creation of better solutions. This is because the instructions encourage the problem-solving process.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
4	Si13.1 A simulation game is an educational method that can be used to teach and then implement what was learned.	M8 Experiential learning **stimulates** the idea of creating while learning M22 Mechanisms used to stimulate learning and negotiation, **are** necessary to handle social processes in local group interaction. M24 Creating a morphological schematic for integrated engineering design **combines** knowledge.	Use methods whereby the meeting participants learn from each other, which lead to a shared result. This occurs because cooperative learning stimulates creative and collaborative working
5	Si12.2 Making independent choices is based on emotions.	M11 Successful teams **use** emotional expressions. M18 A crisis might **restore** a process. M23 Facilitating development processes with more knowledge of human dynamics **enhances** working together.	When facilitating, also respond to non-verbal input and provide a positive response to any reluctance among those in the meeting, which leads to the sustained involvement of group members. This is because emotions enhance collaborative processes.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
6	Si14.2 The Wybert+ model provides structure for the activities necessary for a design meeting. Si 8.2 Postponing judgment during a design meeting is a skill that can be acquired.	M15 Designers **work** by *naming* the relevant factors in the design situation, *framing* this situation in a certain way, making (experimental) *moves* toward a solution and *reflecting* on these moves.	Plan the activities of the design meeting following the basic rhythm of starting, engaging with the problem, reformulating the question, diverging, converging and making plans, this leads to reduced anxious and indifferent behavior. This is because the structure of a creative process consists of the following activities: naming, framing, moving and reflecting.
7	Si14.2 The Wybert+ model provides structure for the activities necessary for a design meeting.	M15 Designers **work** by *naming* the relevant factors in the design situation, *framing* this situation in a certain way, making (experimental) *moves* toward a solution and *reflecting* on these moves.	Carefully (re)formulate a question in a way that will help resolve the most significant problem. This leads to increased support for the plan. This is because the structure of a meeting process consists of the following activities: naming, framing, moving and reflecting.
8	Si7.1 Continued use of an agreed upon analysis and design method supports designers in solving the problems of users (together).	M19 Placing the object in a different context **teaches** participants to look at things in a different way.	Diverge from the scenario when methods no longer work and choose other activities. This leads to the renewed motivation of group members. This should be done because changing frames creates ideas.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
9	Si4.1 Plenary meetings of steering groups and working parties encourage the development of a shared vision. Si8.3 Change the position of the tables and chairs in the room where the design meeting is held.	M12 Creating space and taking charge **fosters** the desired performances. M23 Facilitating development processes with more knowledge of human dynamics **enhances** working together.	Direct the meeting participants to work in alternating situations (alone & together, language & signs, active & passive, standing & sitting, sitting in rows & circle, high impact & relaxed, etc.), this leads to increased utilization of multiple intelligences. This is because changing frames and using emotions enhance collaborative processes.
10	Si6.1 A design tool stimulates the interaction between designers in a team. Si2.3 Doing structured exercises during brainstorming sessions teaches participants how to design together. Si7.1 Continued use of an agreed upon analysis and design method supports designers in solving the problems of users (together).	M7 The personality traits of participants **determine** the working style.	Expressly encourage the meeting participants to move outside of their usual thinking patterns by using creativity techniques. This leads to increased mental capacity that will allow participants to create new ideas. This should be done because otherwise the personality traits of participants will determine the working style.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
11	Si2.3 Doing structured exercises during brainstorming sessions teaches participants how to design together.	M20 Face-to-face working **leads to** increased interaction and collaboration. M23 Facilitating development processes with more knowledge of human dynamics **enhances** working together.	Ensure that the meeting participants are independently engaging each other, this leads to freedom for the facilitator to think about the next activities. This should be done because shifting the responsibility to the participants enhances collaborative working.
12	Si11.1 A drawing, collage or construction needs a story to give it significance.	M9 Graphic techniques **enhance** the quality of ideas. M25.1 Interactive meeting tools **stimulate** embodied cognition.	Also use hands to visualize ideas, this leads to the ability to utilize intangible (tacit) knowledge, dreams and feelings. This is because making use of the talents of the participants enhances involvement.
13	Si8.3 Change the position of the tables and chairs in the room where the design meeting is held. Si8.4 Use special forms of design during the design meeting.	M12 Creating space and taking charge **foster** the desired performances.	Alternate between taking charge and giving space when facilitating methods, this leads to the sustained attention of the meeting participants. This is because creating space and taking charge fosters the desired performances.

No	Successful interventions	Mechanisms	Description of design principles within the context of a design meeting
14	Si11.2 Spoken text must be retained in some other way, e.g. by writing it down.	M4 Reflection **promotes** progression of the process.	Close the meeting by making a visual plan, which includes the tangible answers to the questions, a reflection by the meeting participants regarding the process they have undergone, and how they should progress together. This leads to increased involvement in the future. This is because reflection promotes the progression of the process.
15	Si7.1 Continued use of an agreed upon analysis and design method supports designers in solving the problems of users (together).	M25.1 Interactive meeting tools **stimulate** embodied cognition. M25.2 Interactive meeting tools **make** user values visible.	Use the most suitable method. This leads to the increased ability of the participants to contribute optimally to the ultimate goal. This should be done because making use of the talents of the participants enhances involvement.

4.6.4. Developing the course based on design principles

The development of the course based on design principles is the result of four steps. The first step was to derive the learning objectives from the set of design principles. See the results in Table 4.19.

The second step was to compose the course program based on the above-mentioned learning objectives, the sub-aims (see Chapter 1.3), and the prerequisites (mentioned in section 4.5.4. The duration of the course was two full days (not consecutive) with each day divided into two periods, and an afternoon, evening and day. Prior to the course, the participants are required to study some text books and instructions, and they must facilitate a design meeting in their working environment. The course program is depicted in a table with four columns: period, didactic methods, and associated tools. The table also shows the standard materials that are needed and the desired layout of the course room. See Table 4.20.

The third step is to compose a leaflet to recruit participants. This leaflet gives the title of the course, an explanation of the use of design principles, etc. See Figure 4.16.

The final step is to describe the learning outcomes. These are described in Chapter 6 as part of the validation of the set of design principles.

Table 4.19. Deriving "learning objectives" from "design principles".

No	**Description of design principles within the context of a design meeting**	**Learning objectives** At the end of the course:
1	Develop a scenario for a design meeting in advance by making an appropriate choice from one of the following parameters: aim, participants, tools and control. This leads to a situation in which the facilitator can anticipate a wide variety of situations which help to achieve the desired outcome. This is because from the start, design activities need a well-thought out *name* and *framework*.	The course participants can develop a plan for a design meeting.
2	Ensure that there are a variety of personalities, team roles and skills among the participants of the design meeting. This leads to a wealth of knowledge and a multitude of ideas that can be shared. This occurs because multiple talents stimulate each other.	The course participants can identify different team roles during a design meeting and can utilize the strengths of the people in the design meeting.
3	Use or develop the creative skills of the meeting participants by beginning with a brief creativity exercise using a common or familiar design. This leads to the creation of better solutions. This is because the instructions encourage the problem-solving process.	The course participants can explain creativity techniques in such a way that the people in the meeting are able to use them.
4	Use methods whereby the meeting participants learn from each other, which lead to a shared result. This occurs because cooperative learning stimulates creative and collaborative working	The course participants can select and facilitate methods in such a way that people in the meeting learn from each other.

No	Description of design principles within the context of a design meeting	Learning objectives At the end of the course:
5	When facilitating, also respond to non-verbal input and provide a positive response to any reluctance among those in the meeting, which leads to the sustained involvement of group members. This is because emotions enhance collaborative processes.	The course participants can identify the non-verbal input and reluctance of the people in the meeting and can respond to this in such a way that the people remain involved.
6	Plan the activities of the design meeting following the basic rhythm of starting, engaging with the problem, reformulating the question, diverging, converging and making plans, this leads to reduced anxious and indifferent behavior. This is because the structure of a creative process consists of the following activities: naming, framing, moving and reflecting.	The course participants can maintain the basic rhythm of the design meeting so that the people taking part are continually challenged.
7	Carefully (re)formulate a question in a way that will help resolve the most significant problem. This leads to increased support for the plan. This is because the structure of a meeting process consists of the following activities: naming, framing, moving and reflecting.	The course participants can address the relevant problem using (re)formulating techniques.
8	Diverge from the scenario when methods no longer work and choose other activities. This leads to the renewed motivation of group members. This should be done because changing frames creates ideas.	The course participants can diverge from the plan and can instantly use the methods.
9	Direct the meeting participants to work in alternating situations (alone & together, language & signs, active & passive, standing & sitting, sitting in rows & circle, high impact & relaxed, etc.), this leads to increased utilization of multiple intelligences. This is because changing frames and using emotions enhance collaborative processes.	The course participants can use the didactic methods that make optimal use of the strengths of the people in the meeting.

No	**Description of design principles within the context of a design meeting**	**Learning objectives** At the end of the course:
10	Expressly encourage the meeting participants to move outside of their usual thinking patterns by using creativity techniques. This leads to increased mental capacity that will allow participants to create new ideas. This should be done because otherwise the personality traits of participants will determine the working style.	The course participants can use creative didactic methods that break through fixed thinking patterns and thus create room for new ideas.
11	Ensure that the meeting participants are independently engaging each other, this leads to freedom for the facilitator to think about the next activities. This should be done because shifting the responsibility to the participants enhances collaborative working.	The course participants can facilitate ‘at a distance’ so that the people in the meeting become more active.
12	Also use hands to visualize ideas, this leads to the ability to utilize intangible (tacit) knowledge, dreams and feelings. This is because making use of the talents of the participants enhances involvement.	The course participants can facilitate didactic methods that use hands as a communication tool.
13	Alternate between taking charge and giving space when facilitating methods, this leads to the sustained attention of the meeting participants. This is because creating space and taking charge fosters the desired performances.	The course participants can alternate between taking charge and giving room in order to support the creative process.
14	Close the meeting by making a visual plan, which includes the tangible answers to the questions, a reflection by the meeting participants regarding the process they have undergone, and how they should progress together. This leads to increased involvement in the future. This is because reflection promotes the progression of the process.	The course participants can conclude the meeting with a plan.

No	Description of design principles within the context of a design meeting	Learning objectives At the end of the course:
15	Use the most suitable method. This leads to the increased ability of the participants to contribute optimally to the ultimate goal. This should be done because making use of the talents of the participants enhances involvement.	The course participants can choose a suitable method.

Table 4.20. The creativity facilitation course program.

Period	Didactic methods	Tools
1	By using an object, the course participants tell the group what creative thinking adds to their work.	A number of objects in a bag
1	The lecturer explains the meaning of 'creative thinking in a group'.	PowerPoint presentation, Yellow card, Wybert+ model
1	Small groups of course participants choose a didactic method from a book, and explain to the group why they have chosen it and who will be facilitating it.	Methods book
1	The lecturer explains how the "Systematic Inventive Thinking" (SIT) creativity technique works.	PowerPoint presentation
1	The lecturer writes down issues, which the course participants name, relating to preparing for and leading design meetings.	Flipcharts
1	The lecturer explains a case that must be resolved using SIT. The lecturer explains the use of a plan. Working in sub-groups, the course participants devise a plan.	Case description with video clip, Format of a plan
	Lunch	
2	Three course participants facilitate a design meeting with the other course participants in order to resolve the case using SIT. The lecturers and course participants provide feedback. All course participants take turns facilitating during this period.	Brainstorming tools
2	The lecturer assesses the day using an evaluation technique.	
	A few weeks later	

Period	Didactic methods	Tools
3	The course participants recount their experiences of using a method in their work environment.	
3	The lecturer explains the Belbin team roles.	PowerPoint presentation
3	The lecturer explains how a shared vision can be developed using dream techniques.	PowerPoint presentation
3	The lecturer explains a case that must be resolved using dream techniques. The course participants develop a plan in sub-groups.	
	Lunch	
4	Three course participants facilitate a meeting with the other course participants in order to resolve the case using a dream technique. The lecturers and course participants provide feedback. All course participants take turns facilitating during this period.	
4	The lecturer assesses the day using an evaluation technique. The lecturer explains an assignment that is to be implemented in the participants' work environments.	
	The course participants prepare and run a design meeting in their work environment. This took 6 to 8 weeks.	
5	The course participants present their experiences preparing and leading a design meeting. Former course participants provide feedback on this presentation.	PowerPoint must not be used when presenting experiences. Course participants should devise their own presentation format.
5	The lecturer explains a case that must be resolved using a creativity technique. The course participants develop a plan in sub-groups.	
	Evening	
6	Three course participants facilitate a meeting with the other course participants in order to resolve the case using a creativity technique. The lecturers and course participants provide feedback. All course participants take turns facilitating during this period.	

Period	Didactic methods	Tools
	Lunch	
7	Three course participants facilitate a meeting with the other course participants in order to resolve the case using a creativity technique. The lecturers and course participants provide feedback. A sub-group provides an energizer.	
7	The lecturer assesses the day and the course using an evaluation technique.	

Intake and farewell interviews
Prior to the course, individual interviews were conducted to obtain insight into the level of skills and motivation of the course participants. These interviews were repeated after the course to determine the degree to which the information and skills learned in the course had been embedded in the participants' professional environments and to help them reflect on their participation. These interviews will provide insight into the course participants' disciplines, intelligences and learning styles.

Standard didactic methods
During the course, a number of standard didactic methods are selected, such as methods for people to get acquainted, PowerPoint presentations, exercises alone and in a group, case study exercises, handouts, a list of relevant literature, homework exercises, and materials for creativity techniques. The participants can work alone, in a group of 2-3 people, and in a group of 4 or more.

Standard tools
The standard tools can be mobile flipcharts, various sizes of Post-It notes, colored pencils, inspirational images, colored stickers, mobile white board, etc.

Course room
The following are requirements for the room in which the meeting is to be held: open floor space; moveable furniture; must be feasible to work in small groups; sufficient daylight; size: 40 to 60 square meters

Belbin test
In order to take into account the consider individual differences between participants, the course participants performed a Belbin test (Claessen, Van Hezel, Van der Naald, and Nijenhuis, 2006) in order to establish what their Belbin team roles would be.

School books
The course members were required to study two books: *Systematic Inventive Thinking* (SIT) by Heere et al. (2005); and *Het grote werkvormenboek* [The Big Methods Book] by Dirkse-Hulscher and Talen (2007).

One period is approximately 3.5 to 4 hours.

The creativity facilitation course based on Handstorm principles

This course teaches professionals in the AEC sector how to plan, organize and conduct creative face-to-face meetings by using a set of design principles.
The focus of the course is (i) oriented to the AEC-sector, (ii) about involved facilitation, (iii) about stimulating cooperative learning, (iv) about using varied skills and intelligences, (v) about creating an open culture, and (vi) about consulting a set of design principles.

Set of design principles that forms the basis of the course
The set consists of 15 design principles that can be briefly described as follows: *plan a detailed meeting plan, invite a variety of participants, explain working methods in a simple way, have participants listen to each other, put a reluctant participant to work, create rhythm in activities, reformulate the question, don't be afraid to deviate from your meeting plan, continually change the circumstances, take participants out of their comfort zone, let the participants do the work, let the hands do the thinking, alternate between strict and lenient, close the meeting with perspective, choose the working method most appropriate for your meeting.*

What you learn
After the course, the participant will know what creative and collaborative thinking is and will have enhanced his/her creative behavior and creative leadership.

For whom
For professionals in the AEC sector who are working as a director, manager, supervisor or engineer with a degree from a university or university of applied sciences, primarily in technical sciences.

Themes
The following themes will be discussed: creative thinking in a group, creative skills and techniques, planning a creative meeting by making a scenario, using the design principles, the group dynamic aspects, the role of the facilitator, and using tools.

Didactic methods
The learning approach is primarily doing exercises. During the course, the participants will plan and conduct a creative meeting four times. Shortly after each meeting participants reflect on the scenario and on the facilitation process. The maximum number of participants is 10.

Trainers
The course will be presented by two trainers: one with a background in construction management and engineering, and creative and collaborative working, and another with a background in group dynamics and personal development.

Study load
The study activities will take up 3.5 days and homework will consist of studying books and facilitating a design meeting at the student's place of employment.

Figure 4.16. Creativity facilitation course leaflet for AEC professionals.

4.7. Reflections and conclusions

The research activity *reflection-in-action* (depicted in Figure 2.1 as the knowledge stream) develops new scientific knowledge. The following sections will first reflect on the creativity facilitation course based on design principles and then on the developing process. Finally, the conclusions will be presented.

4.7.1. Reflections on the creativity facilitation course based on design principles

The reflection on the creativity facilitation course design based on principles consists of the following activities: recognizing the three meeting parameters in the set of design principles, exploring the design principles, and showing that the design principles strengthen the course sub-aims.

Meeting parameters

The meeting parameters control (C), participants (P) and tools (T) can influence the meeting activities and the meeting output. Therefore, it is appropriate to know if these parameters are recognizable in the design principles. In Table 4.21, the most relevant parameter for each design principle has been indicated, and a justification has been given.

Table 4.21. The design principles (DP) and their allocation to a parameter.

DP	Short description of the design principles	Parameters	Justification of parameter choice
1	Plan a detailed meeting plan	C	The meeting scenario controls the meeting.
2	Invite a variety of participants	P	Participants can be chosen.
3	Explain working methods in a simple way	T	A method/tool must work.
4	Have participants listen to each other	P	Make sure that the participants take part in the discussion.
5	Put a reluctant participant to work	P	Do not lose the reluctant participants; they are very valuable.
6	Create rhythm in activities	C	Pressure and release creates energy.
7	Reformulate the question	T	The creativity tool ‘reformulating the question’ at the start of a meeting is crucial.
8	Don’t be afraid to deviate from your meeting plan	C	If the scenario does not work, change it to what is necessary.
9	Continually change the circumstances	C	Bring energy into the group by using various tools.
10	Take participants out of their comfort zone	P	Participants are looking to see what will happen.

DP	Short description of the design principles	Parameters	Justification of parameter choice
11	Let the participants do the work	P	Let do the participants the work so the facilitator can think about the process.
12	Let the hands do the thinking	T	Tools that involve hands give a richer result.
13	Alternate between strict and lenient	C	This control approach is effective.
14	Close the meeting with perspective	T	Choose a tool that gives a perspective at the end of a meeting.
15	Choose the working method most appropriate for your meeting	T	Choose or design a tool that fits with the aim and the participants.

DP = Design Principle
C = Control, P = Participant, T = Tools

Based on Table 4.21, an overview has been created that shows how the three meeting parameters are spread among the 15 design principles. It appears they are uniformly divided among the control, participants and tools parameters.

Explanation of design principles
An explanation has been given for each design principle. Table 4.22 presents an overview of the principles. The explanations clarify the design principles, with references to scientific literature, and indicate the motivation for acting in a certain way.

Table 4.22. Explanation of the design principles.

DP	Short description of the design principles	Description of design principles within the context of a design meeting	Explanation
1	Plan a detailed meeting plan	Develop a scenario for a design meeting in advance by making an appropriate choice from one of the following parameters: aim, participants, tools and control. This leads to a situation in which the facilitator can anticipate a wide variety of situations which help to achieve the desired outcome. This is because from the start, design activities need a well-thought out *name* and *framework*.	Formulating a scenario forces the facilitator to consider in advance what interventions to use and how the related mechanism will function. Writing out the scenario in advance makes it easier to improvise when unexpected situations occur during the design meeting because alternatives will be more readily available.
2	Invite a variety of participants	Ensure that there are a variety of personalities, team roles and skills among the participants of the design meeting. This leads to a wealth of knowledge and a multitude of ideas that can be shared. This occurs because multiple talents stimulate each other.	In the AEC sector, a facilitator does not always have control over who attends the design meeting. Nevertheless, variety can be created by inviting additional participants. If there is very little control over who participates in the meeting, try to find suitable formats for the participants.
3	Explain working methods in a simple way	Use or develop the creative skills of the meeting participants by beginning with a brief creativity exercise using a common or familiar design. This leads to the creation of better solutions. This is because the instructions encourage the problem-solving process.	Avoid working with an unfamiliar creativity technique when developing the actual ideas. First practice the new technique so that participants can improve their skills. This mechanism does not work if the participants already have experience using a creativity technique.

DP	Short description of the design principles	Description of design principles within the context of a design meeting	Explanation
4	Have participants listen to each other	Use methods whereby the meeting participants learn from each other, which lead to a shared result. This occurs because cooperative learning stimulates creative and collaborative working	Designing together also means learning together.
5	Put a reluctant participant to work	When facilitating, also respond to non-verbal input and provide a positive response to any reluctance among those in the meeting, which leads to the sustained involvement of group members. This is because emotions enhance collaborative processes.	Architectural designers are generally not particularly talkative. If this is the situation, a facilitator may enhance involvement by giving participants more time, allowing them to work on their own, or having them draw their ideas. REF
6	Create rhythm in activities	Plan the activities of the design meeting following the basic rhythm of starting, engaging with the problem, reformulating the question, diverging, converging and making plans, this leads to reduced anxious and indifferent behavior. This is because the structure of a creative process consists of the following activities: naming, framing, moving and reflecting.	This design principle is partly based on the theory of (group) flow by (Csíkszentmihályi, 1990). Use appropriate activities or interventions to balance challenges and the different competencies of the participants.

DP	Short description of the design principles	Description of design principles within the context of a design meeting	Explanation
7	Reformulate the question	Carefully (re)formulate a question in a way that will help resolve the most significant problem. This leads to increased support for the plan. This is because the structure of a meeting process consists of the following activities: naming, framing, moving and reflecting.	The starting question is not always the most appropriate question to start with. Exploring other questions and sharing them may be useful. See the theory of challenge mapping that was developed by Basadur (2002).
8	Don't be afraid to deviate from your meeting plan	Diverge from the scenario when methods no longer work and choose other activities. This leads to the renewed motivation of group members. This should be done because changing frames creates ideas.	Each scenario may develop its own group dynamics, as a result of which the scenario might no longer be effective. Dare to diverge from the scenario and respond to what is happening.
9	Continually change the circumstances	Direct the meeting participants to work in alternating situations (alone & together, language & signs, active & passive, standing & sitting, sitting in rows & circle, high impact & relaxed, etc.), this leads to increased utilization of multiple intelligences. This is because changing frames and using emotions enhance collaborative processes.	Participants usually devise solutions using the intelligence in which they thrive. Creating alternating situations helps to identify the participants' actual talents.

DP	Short description of the design principles	Description of design principles within the context of a design meeting	Explanation
10	Take participants out of their comfort zone	Expressly encourage the meeting participants to move outside of their usual thinking patterns by using creativity techniques. This leads to increased mental capacity that will allow participants to create new ideas. This should be done because otherwise the personality traits of participants will determine the working style.	Ideas are generated when fixed patterns are broken, freeing up room to think (Van Gassel et al., 2013).
11	Let the participants do the work	Ensure that the meeting participants are independently engaging each other, this leads to freedom for the facilitator to think about the next activities. This should be done because shifting the responsibility to the participants enhances collaborative working.	Participants tend to make the facilitator responsible for executing activities during a design meeting. They are less likely to do so when the facilitator takes a back seat. Dare to leave the group alone.
12	Let the hands do the thinking	Use hands to visualize ideas, this leads to the ability to utilize intangible (tacit) knowledge, dreams and feelings. This is because making use of the talents of the participants enhances involvement.	Hands can be used to make complex thinking steps explicit/ visible. Examples of the visualization of thoughts are gestures, drawings, objects, etc.
13	Alternate between strict and lenient	Alternate between taking charge and giving space when facilitating methods, this leads to the sustained attention of the meeting participants. This is because creating space and taking charge fosters the desired performances.	Applying pressure and letting go sustains momentum. In human processes, progress is maintained with rhythm, which tends to alternate between taking charge and giving room. This principle can also be applied in a group process.

DP	Short description of the design principles	Description of design principles within the context of a design meeting	Explanation
14	Close the meeting with perspective	Close the meeting by making a visual plan, which includes the tangible answers to the questions, a reflection by the meeting participants regarding the process they have undergone, and how they should progress together. This leads to increased involvement in the future. This is because reflection promotes the progression of the process.	A lack of perspective or a follow-up action plan decreases the motivation for a similar challenge.
15	Choose the working method most appropriate for your meeting	Use the most suitable method. This leads to the increased ability of the participants to contribute optimally to the ultimate goal. This should be done because making use of the talents of the participants enhances involvement.	Making optimal use of the participants' qualities requires the clever deployment of participants and tools in relation to the aim. In business terms, this means aiming for maximum effectiveness and efficiency (In 't Veld, 1992).

Strengthen the sub-aims

In Chapter 1.3, six sub-aims were discussed. The set of design principles to plan, organize and conduct design meetings satisfies to the 6^{th} sub-aim. For the other five sub-aims, Table 4.23 shows that the set of design principles strengthens the sub-aims of the course to a certain extent. For each design principle in the table, there is an explanation of why this principle best strengthens the sub-aim. The score is (i) oriented to the AEC-sector (four times), (ii) involved facilitation (three times), (iii) stimulating cooperative learning (one time), (iv) using varied skills and intelligences (five times), and (v) creating an open culture (five times). The sub-aims (iii) and (iv) are weakly supported by the set of design principles.

Table 4.23. Design principles matched to five sub-aims.

Number	Sub-aims	Oriented to the AEC sector	Involved facilitation	Stimulating cooperative learning	Using varied skills and intelligences	Creating an open culture
		(i)	(ii)	(iii)	(iv)	(v)
	Key-values	Responsibility Customer-directed Letting go	Engagement Enterprising spirit Proactive	Empathy Eagerness to learn Synergy	Playfulness Imagination Inventiveness	Transparency Reflecting Respect
	Short description of design principles					
1	Produce an accurate meeting scenario					Be open about the agenda
2	Invite a variety of participants	Invite clients				
3	Explain method in simple terms				Involve everybody in activities	
4	Have participants listen to each other			Learn to listen		
5	Set a reluctant participant to work	Take everyone seriously				
6	Give rhythm to activities		Keep the initiative			
7	Reformulate the question	Research the question behind the question				
8	Do not adhere strictly to the scenario		Maintain contact between the participants			
9	Continuously change the circumstances				Try to reach every participant	
10	Take participants out of their comfort zone	Avoid routines				
11	Make the participants do the work				Stimulate playing	
12	Let the hands do the thinking				Do not only use verbal skills	
13	Alternate between strict and relaxed		Change in style			
14	End with perspective					Reflect on process and give perspective
15	Choose the most effective method for the meeting				Match the techniques with the talents	

4.7.2. Reflections on the course developing process

Designing and developing are reductive reasoning processes in which prerequisites (e.g., values) are transformed into form (e.g., a design) (Roozenburg & Eekels, 1998). These are processes in which the design is developed in various iterative steps. As such, different designs may result from the same prerequisites. It is advisable to examine which conditions could result in an alternative design. These conditions can be found by considering a number of sources, such as respondents, instruments, researchers, and circumstances.

The following conditions have been identified:

- Of the 28 Ph.D. studies, two originated outside the Netherlands, namely in Great Britain and Denmark. However, the Dutch studies are internationally oriented.
- Seven of the 14 experiments were conducted in collaboration with the AEC sector; the other seven were performed at Eindhoven University of Technology.
- The Ph.D. studies and experiments were conducted independently of each other between 1975 and 2014.
- Most of the experiments were conducted by the researcher in collaboration with other researchers.
- The results of almost all of the experiments were published – either in proceedings, professional reports, professional publications and/or in internal reports – but none were published in scientific articles.
- The experiments were not conceived in conjunction, but were the outcome of individual tutorials, symposiums, contract research, etc.
- The researcher's expertise is in the domain of construction management and engineering (in this case, the AEC sector). In a different discipline, such as cognitive psychology or group dynamics, the formulation of the design principles may have been different.
- This study was conducted in the AEC sector, which is dominated by (male) engineers. It is conceivable that the design principles work better for this target group and may be less effective for other professionals, such as biologists or entrepreneurs.
- The course has been developed for a specific company and within the constraints of a business school. These constraints affected, for example, the number of course days, financing participation costs and available participants.

In summary, the development of the course based on design principles is mainly based on a series of Ph.D. studies and experiments that were done in a Dutch context. If this study had been conducted in a more international context, the cultural angle of the design principles might have been different. The same is true if the study had been conducted by a researcher in a different field or from a different research discipline.

The design science research approach had an impact on the research activities that were used. The design principles and course program were developed using the research-design-development cycle, with research findings and practices as the sources. Three applied research activities were devised by the researcher: (i) a synthesis of conclusions from Ph.D. studies and from experiences of the researcher during experiments in the AEC sector, (ii) a design solution or a creativity facilitation course based on a set of design principles, and (iii) a reflection on that and on its design process. These research activities, which are part of the design science research approach, are more qualitatively than quantitatively oriented.

4.7.3. Conclusions

The second main research topic, *Developing the creativity facilitation course based on design principles,* is addressed by first developing a set of 15 design principles and then using these principles to develop the course program. The set of design principles strengthen the sub-aims of the course to a certain extent. Conditions were discussed which could result in another design, and three applied research activities within the design science research approach have been devised by the researcher.

The validity of the set of design principles will be determined in Chapter 5 by implementing and evaluating the course.

The loose letters of 'creative thinking' not allow you to make different words, you can also make pictures with them if you can stop thinking of anagrams. (Letters made by employees of the Borg Foundation's wood workshop, Haarlem).

Chapter 5
Validating the set of design principles[7]

5.1. Introduction

In this chapter, the third main research topic, *Validation the set of design principles,* will be tackled. The design principles, upon which the development of the creativity facilitation course has been based, are listed in Table 4.22.

First, the activities that are necessary to validate the set of design principles will be discussed. Then the sub-topics that must be addressed will be identified. Next, the results will be presented and then assessed for validity. Finally, results in this chapter will be summarized.

5.2. Validation activities

The validation of the set of design principles will be done pragmatically, which means that the course based on the set of design principles will be evaluated. As mentioned in Chapter 2.4, this validation will require three activities: Activity D: Evaluating the course by implementing it in practice and then measuring the learning outcomes of the course participants; Activity E: Qualifying the implementation of the set of design principles; and Activity F: Assessing the validity of the evaluation and qualification results by applying the *plausible rival explanations* method. The plausible rival explanation method is, according R.K. Yin (2013), "an extremely promising but still underdeveloped procedure for strengthening the validity of case study evaluations" (p. 323). Yin also stated that data triangulation – the use of different samples, spaces and persons (Denzin, 2006) – is a supplementary procedure that can be used to further demonstrate the validity.

The results of these activities will deliver an estimation of the validity of the set of design principles. In Figure 5.1, the activities are connected with each other by arrows that stand for input or output.

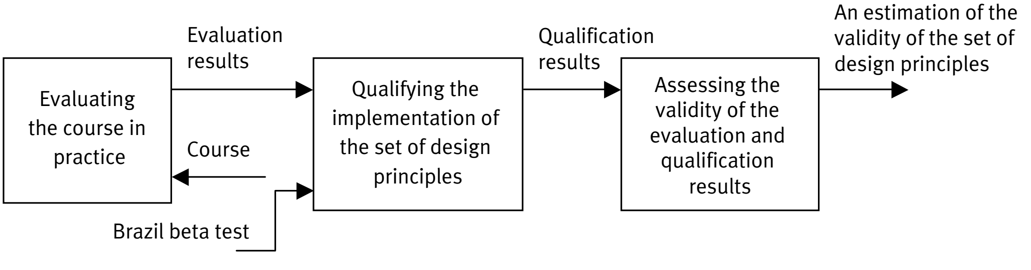

Figure 5.1. Activities to validate the set of design principles.

[7] This chapter is based on a draft article for a scientific journal and was written in cooperation with Isabelle Reymen, Eindhoven University of Technology

5.3. Method

The third main research topic, *validating the set of design principles,* and the activities mentioned in the previous section lead to the following three sub-topics:

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

The methods used to carry out the activities associated with these two sub-topics will be explained in the following two sections. In the last sub-section, the method used to assess the validity of the design principles also will be described.

5.3.1. Evaluating the course in practice

The course has been evaluated by implementing the course program in practice and then measuring the learning outcomes. How the sample and the measurements were chosen will be described hereunder.

Sample

The best way to evaluate the creativity facilitation course is to implement the course a number of times according the description of the course program (Table 4.20) and as stated in the course leaflet (Figure 4.16).

From 2009 until the spring semester of 2014, the course was given ten times to 99 BAM Group employees. The 56 participants of the first six courses (which took place between spring 2009 and spring 2012) were invited by email to complete a questionnaire. It was also announced during a networking meeting of ex-course participants that the effects of the course would be measured with a questionnaire. The course participants were then asked via a telephone call from a research assistant if they would come to an appointment with the researcher of this study, so that the questionnaire could be completed in his presence.

The course participants held various positions such as director, manager, supervisor or engineer and worked at one of the following Dutch BAM operating companies: BAM Utiliteitsbouw, BAM Wegen, BAM Civiel, BAM Techniek, BAM Rail, BAM PPP (Public-Private Partnership) and Vitaal ZorgVast. The course also became a part of the program at BAM Business School. Royal BAM Group is a European construction group that is comprised of operating companies in five home markets and that is active in construction, mechanical and electrical services, civil engineering, property management, and public-private partnerships. See the website of the Bam Group (www.bam.nl). Employees of the BAM operating companies were eligible to take part in the course. The operating companies paid for the course. The course description was included in the BAM Business School training leaflet (BAM, 2010). An impression of the first course was also published in the company magazine, *BAM Breed*.

These six courses were attended by various professionals from the AEC sector, creating a representative sample to evaluate the creativity facilitation course, despite the fact that all of the participants are employed by one large company. The sample does lack course participants who work in independent small companies.

Measurements

To evaluate the course, the learning outcomes must be measured and the participants' characteristics must also be examined in order to gain insight into the sample.

The participants' characteristics (independent variables) are the following:

- 'completed education' (CE),
- 'subsidiary company work' (CW),
- 'work experience' (WE) in years,
- 'job description'(JD), and
- 'date of training' (DT).

The learning outcomes mentioned in Chapter 4.3.5 (dependent variables) are the following:

Regarding skills:

1. 'knowledge of creative and collaborative thinking' (CT),
2. 'creative behavior' (CB),
3. 'enhancing creative behavior' (ECB),
4. 'creative leadership behavior' (CL),
5. 'enhancing creative leadership behavior' (ECL),

Regarding attitude:

6. 'course satisfaction' (CS),
7. 'facilitating design meetings per month after course' (FM), and
8. 'working on learned skills after course' (WS).

According to Kirkpatrick and Kirkpatrick (2010), the most important measurement is that of the extent of the course member's change in behavior; however, they state that it is also necessary to measure the level of learning because a certain level of learning is required in order to achieve a change in behavior. Therefore, in this study, the effect of teaching the 'knowledge of creative and collaborative thinking' (CT) has been measured.

The survey was conducted by having the participants answer written questions. The measurements of the eight independent variables will be described in more detail below. The complete survey is available upon request.

The first dependent variable, 'knowledge of creative and collaborative thinking' (CT), was measured with a multiple choice test containing 16 questions with three possible answers and one open-ended question. The questions tested whether the participants remembered, understood and were applying the basic elements the course was supposed to have taught them. These basic elements are the following: 'creative and collaborative thinking' (2 questions), 'rhythm' (1 question), 'techniques' (5 questions), 'creative thinking skills' (3 questions), 'processing ideas' (4 questions) and 'preparation for a meeting' (1 question). The design of the test is based on the educational testing service manual written by Baldwin, Fowles, and Livingston (2008) and includes a correction for the guessing factor. The percentage of questions that would on average be answered correctly by guessing is 33% * 16 = 5.28. Six points were deducted from each participant's assessment score to account for this, so that the assessment scores ranged from 0 to 10. A score of 5.5 could therefore be regarded as 'sufficient'. This measurement delivered the average assessment score related to the variable 'knowledge of creative and collaborative thinking' (CT).

The second dependent variable, 'creative behavior' (CB), aims to determine the level of creative behavior of the course participants. Amabile, Conti, Coon, Lazenby, and Herron (1996) described the creativity of participating individuals and team members as the "production of novel and useful ideas in any domain" (p. 1135). Creative behavior helps the employee contribute to the organization's innovation process. The creative behavior of the employee can be influenced by the social environment. Based on this description, a measurement scale for 'creative behavior' was developed by George and Zhou (2001), whereby the questions were answered by the supervisor. This measurement scale was translated by Noordam (2006) into a Dutch language, self-reporting questionnaire containing 12 items. The statements were adopted verbatim from a study by Van Sele (2009) at Ghent University. An example of a statement is: "In my job I propose new ways of achieving targets". The other 11 items can be summarized by the following key phrases: I generate ideas, I generate technologies, I improve quality, I'm a source of ideas, I promote ideas, I'm creative, I implement techniques, I have new ideas, I propose new ideas, I have innovative visions, and I introduce new working methods. Scoring is based on a 5-point Likert scale: 1 = 'Never', 2 = 'Rarely', 3 = 'Sometimes', 4 = 'Often' and 5 = 'Always'. The total score shows the level at which the people completing the survey assess their behavior as creative. For the Van Sele (2009) study, the Cronbach's Alpha–an indication of the extent to which the items in a questionnaire measure the same concept (Field, 2009)–was 0.92 for this set of questions. This measurement delivered the average assessment score related to 'creative behavior' (CB).

The third dependent variable, 'enhancing creative behavior' (ECB), measured to what extent this behavior had been enhanced. Since we were unable to conduct both pre- and post-measurements, Kirkpatrick and Kirkpatrick (2010) recommend asking the course participants to what extent attending the course had actually contributed to a change in his/her behavior. This change in creative behavior was also measured in the survey by asking for each sub-question "To what extent has the training contributed to a change in the mentioned behavior?" Participants could choose from the following responses: 'to a large extent', 'to some extent', 'no change' and 'made it worse'. This measurement delivered the average assessment score related to 'creative behavior' (CB) and 'enhancing creative behavior' (ECB).

The fourth dependent variable, 'creative leadership behavior' (CL), aims to determine to what extent the course members are behaving creatively. When measuring 'creative leadership behavior', questions related to leadership were adopted from a self-assessment entrepreneurship test (Goossens & Verrue, 2004). According to Laevers and Bertrands (2004), entrepreneurship is a powerful mix of two well-developed dispositions: self-directed learning and creativity. According to Geraets (2007), in the self-assessment test, creative leadership consists of the following aspects: (i) Mobilizing and uniting, (ii) Synthesizing and structuring, (iii) Decision-making, (iv) Sharing and delegating, (v) Having an overview and re-adjusting, (vi) Coaching and (vii) Responsibility. All seven of these concepts from the self-assessment test have been formulated as multiple-choice questions and were converted to measure 'creative leadership behavior'. See Appendix C. A Cronbach's alpha is not known for the above measurement. This measurement delivered the average assessment score related to 'creative leadership behavior' (CL).

The fifth dependent variable, 'enhancing creative behavior' (ECB), measured to what extent the participant's creative behavior was enhanced as a result of the course. In addition, after each item the course participants were asked to state to what extent attending the course had actually contributed to a change in the mentioned behavior, using the scale: 'to a large extent', 'to some extent', 'no change' and 'made it worse'. This measurement delivered the average assessment score related to 'enhancing creative leadership behavior' (ECL).

The sixth dependent variable, 'course satisfaction' (CS), measured to what extent the course participants were satisfied with the course. Their level of satisfaction was measured using a question and a 4-point Likert reply scale that ranged from 'Very dissatisfied', 'Dissatisfied', 'Satisfied' to 'Very satisfied'. This scale was taken from the *info-line* publication from the American Society for Training & Development (ASTD) (Falletta & Combs, 2007).

The seventh dependent variable, 'facilitating design meetings per month after course' (FM), measured how many design meetings the participant had facilitated (or helped to facilitate) after the course.

The eighth dependent variable, 'working on learned skills after course' (WS), was also measured using a question with a 4-point Likert reply scale that ranged from 'Never', 'Seldom', 'Sometimes' to 'Often'. This scale was taken from the publication *Building Capacity in Evaluating Outcomes* (Wisconsin & Taylor-Powell, 2008).

The final question of the survey was an open-ended question asking for individual comments about the course.

The responses to the survey questions for all of the above measurements were entered into the IBM SPSS Statistics 20 program. The data acquired from the survey was intended to deliver an estimation of the validity of the set of design principles.

5.3.2. Qualifying the implementation of the set of design principles

The qualification of the implementation of the set of design principles involves considering the measurement results of the learning outcomes and demonstrating the coherence between the learning outcomes CT, CB and CL and the set of design principles. A certain level of coherence is necessary because the measurements of these learning outcomes have not been directly derived from the design principles or the learning objectives. The qualifying also involves considering the outcome of the beta test.

In this section the methods used to measure the learning outcomes and to demonstrate the coherence between the learning outcomes and the set of design principles will be clarified and a report about the beta test will be cited.

Learning outcomes and coherence with the set of design principles

The mean of the following learning outcomes will be considered: 'knowledge of creative and collaborative thinking' (CT), 'creative behavior' (CB), 'enhancing creative behavior' (ECB), 'creative leadership behavior' (CL), and 'enhancing creative leadership behavior' (ECL). Further, the outcomes of 'course satisfaction' (CS) and 'working on learned skills after course' (WS) will be depicted. Finally, the value of the variable 'facilitating design meetings per month after course' (FM) will be mentioned.

The coherence between the three learning outcomes, or the survey questions, with the 15 design principles will be demonstrated in Table 5.6. The 15 design principles are depicted horizontally. The following variables are listed vertically on the table: 'knowledge of creative and collaborative thinking' (CT) which is divided up in six sub-groups of questions: 'collaborative creative thinking', 'rhythm', 'techniques', 'creative thinking skills', 'processing ideas' and 'preparation'; the 'creative behavior' (CB); and the 'creative leadership behavior' (CL). The coherence can be demonstrated by matching the keywords in the text of the design principles with the text of the survey in relation to the survey questions. The following algorithm was developed in EXCEL to find the matches: =IF(ISNUMBER(FIND("keyword cell"; "question/answers cell"));1;0). This type of research tool originates from the methodology used to find bisociations. This methodology involves the substantive comparison of two texts from different domains in order to arrive at new knowledge (Segond & Borgelt, 2010). From the text of the 15 design principles, 242 keywords were chosen (Mean 16.1, Max 26 and Min 10). The total number of possible matches is thus 6,050.

Beta test
In 2005, a preliminary version of the design principles was published previously in scientific articles in order to invite users to experiment with them and to receive feedback about them. During vision design sessions, some design principles were applied in a bachelor's degree course for Fashion Design at SENAI CETIQT in Rio de Janeiro, Brazil (Pinheiro & Queiroz, 2013; Queiroz, Volpini, & Simão, 2016). The lecturers of this course based their approach on the Handstorm method and the effect measurement was based on the article "Experiences with collaborative design by constructing metaphoric objects" (Van Gassel, 2005).

5.3.3. Assessing the validity of the evaluation and qualification results

The *plausible rival explanation* method is suitable to further demonstrate the validly of the course evaluation and subsequently the qualification of the implementation of the set of design principles. This validity assessment (i) consists of identifying the plausible rivals and (ii) explaining how these rivals can be disqualified. According to Yin (2000; 2003), who is mentioned in Ropes (2010), rivals can be classified as either *craft rivals* (i.e. null hypothesis, threats to internal and external validity, bias on the part of the researcher) or *real-life rivals* (i.e. plausible rival explanations that are related to the intervention, implementation and theory and to the external circumstances).

5.4. Results

5.4.1. Evaluating the course in practice

The evaluation of the creativity facilitation course has been carried out by implementing the course and by measuring the learning outcomes.

Implementation course
The implementation of the course has been described in Section 5.3.1. The course participants initiated collaborative activities after the first six courses, which potentially indicate that the skills they learned have reached some degree of internalization. The course participants organized three networking meetings (January 2011, September 2012 and June 2013) during which they exchanged experiences with facilitating design meetings by using poster presentations and by collectively practicing the new techniques. A number of course

participants opened a BAM Portal, through which former course participants could offer their services as facilitators and from which information about creativity techniques could be obtained. Figure 5.2 shows some images of the course participants at work during the creativity facilitation courses.

Figure 5.2. Images of the creativity facilitation course.

Measurements learning outcomes
The 56 participants of the first six courses (which took place between spring 2009 and spring 2012) were invited to complete a questionnaire. As 44 of the course participants completed the questionnaire between October 2012 and January 2013, a response rate of 78.6% was achieved. Three course participants could no longer be contacted because they had started to work for a different employer. The research was able to meet 32 of the course participants. Upon completion of the questionnaire, the researcher provided explanations, answered questions, asked for further details about comments, and took notes. The remaining 24 course participants were subsequently invited to complete the questionnaire on their own and to return it to the researcher. Twelve of those course participants did so.

Table 5.1 shows the measurement results (absolute frequency (N) and percent per sub-variable) of the following independent variables: ‘completed education’ (CE), ‘subsidiary company work’ (CW), ‘job description’ (JD), and ‘date of training’ (DT). The variable ‘completed education’ (CE) shows that the course participants were evenly divided between those with a university education and those with a polytechnic education. Course participants from BAM Wegen, BAM Civiel and BAM Rail, were well represented. The ‘Job descriptions’ (JD) match with the jobs that were depicted in Chapter 4.5.4. Course participants from all six of the courses completed the questionnaire; the least represented course still had four participants who completed the questionnaire. The results of the variable ‘work experience’ (WE) are as follows: mean 18.53 years, standard deviation 7.872 years, maximum 40 and minimum 3 years. Most of the course participants had a considerable amount of work experience.

Table 5.1. Measurement results of four dependant variables.

Dependent variables	Abbr.	Sub-variables	N	Percent
Completed education	CE	Technical University	14	31.8
		University	6	13.6
		Polytechnic	22	50.0
		Other	2	4.5
		Total	44	100
Subsidiary company work	CW	BAM PPP	8	18.2
		BAM Wegen	5	11.4
		BAM Civiel	11	25.0
		BAM Infratechniek	2	4.5
		BAN Techniek	1	2.3
		Vitaal Zorgvast	4	9.1
		BAM Rail	4	9.1
		BAM Utiliteitsbouw	1	2.3
		BAM Leidingen & Industrie	2	4.5
		BAM Infraconsult	5	11.4
		Other	1	2.3
		Total	44	100
Job description	JD	Director	7	15.9
		Manager	20	45.5
		Chief	12	27.3
		Engineer	5	11.4
		Total	44	100
Date of training	DT	2009-1	8	18.2
		2010-1	9	20.5
		2010-2	7	15.9
		2011-1	4	9.1
		2011-2	8	18.2
		2012-2	8	18.2
		Total	44	100

The results of the measurements of the dependent variables 'knowledge of creative and collaborative thinking' (CT), 'creative behavior' (CB), 'enhancing creative behavior' (ECB), 'creative leadership' (CL), 'enhancing creative leadership' (ECL), and 'design meetings facilitated per month after the course' (FM) have been described by the following: the 'number of reactions' (N), a 'score' on a scale (Mean), the 'standard deviation' (SD), 'minimum' (Min), 'maximum' (Max), and the Cronbach's alpha, which are depicted in Tables 5.2-5.5.

Some remarkable results shown in Table 5.2 are that CT scored 7.14 on a scale of 1 to 10 and the variables CB, ECB, CL and ECL scored between 3.008 and 3.541 on a scale of 1 to 4. The Cronbach's alpha for CL is low compared to the outcomes of the other variables.

Table 5.2. Survey variables and measurement results.

Variable	Abbr.	N	Mean	SD	Min	Max	Cronbach's alpha
Knowledge of creative and collaborative thinking	CT	44	7.14[1]	1.488	10	16	
Creative behavior	CB	41	3.541	0.3667			0.816
Enhancing creative behavior	ECB	41	3.008	0.3670			0.839
Creative leadership behavior	CL	44	3.231	0.3145			0.384
Enhancing creative leadership behavior	ECL	44	3.390	0.4217			0.810
Facilitated design meetings per month after course	FM	44	0.325	0.022	0	1	

[1] Corrected for guessing factor 13.14 - 6 = 7.14

Table 5.3 shows the scores of seven sub-variables of the variable 'enhancing creative leadership behavior' (ECL). These scores are the following: the number (N) of reactions, 'enhancing creative leadership behavior' (ECL) on a scale of 1 to 4 (Mean), and the standard deviation (SD) of the mean. The scores in Table 5.3 tell us that 'Overview and readjusting' and 'sharing and delegating' scored lower than the other sub-behaviors.

Table 5.3. Enhancing creative leadership behavior (ECL) per sub-variable.

Sub-variable	N	Mean	SD
Mobilizing and uniting	44	3.64	0.487
Synthesizing and structuring	44	3.07	0.789
Decision-making	44	3.59	0.658
Sharing and delegating	44	2.82	0.896
Overview and readjusting	44	2.43	0.661
Coaching	44	3.30	0.701
Responsibility	44	3.77	0.476

Table 5.4. This table shows the level of 'course satisfaction' (CS) of the 44 course participants; thus 23 (52.3%) were 'satisfied' and 21 (47.7%) were 'very satisfied'.

Table 5.4. Level of course satisfaction (CS).

Level of satisfaction	N	%
Very dissatisfied	0	0.0
Dissatisfied	0	0.0
Satisfied	23	52.3
Very satisfied	21	47.7

Table 5.5 shows the extent to which the course participants further 'worked on learned skills after training' (WS); approximately 90% had worked on it 'sometimes' or 'often'.

Table 5.5. Further work on skills after training (WS).

Worked on skills after course	**N**	**%**
Never	0	0.0
Rarely	4	9.1
Sometimes	26	59.1
Often	14	31.8

The last measurement was an open-ended question that asked participants to give some comments about the course. Some arbitrarily chosen written comments from the survey are "Practice making the course participants enthusiastic", "Creativity techniques are suitable for analytical, policy and strategic sessions", "Little group dynamics due to diverse capabilities of the course participants". The researcher also noted the following verbal comments: "Got to know and respect participants during design meetings", "Also learned social skills", "I don't need to be creative, but the group does", and "It's important to give guidance to participants in a meeting". These comments illustrate why course participants were (very) satisfied with the course. All of the comments are listed in Appendix D.

5.4.2. Qualifying the implementation of the design principles

Learning outcomes and coherence with the set of design principles
In summary, the learning outcomes delivered the following scores: 'knowledge of creative and collaborative thinking' (CT): mean 7.14, on a scale of 1 to 10, 'creative behavior' (CB), 'enhancing creative behavior' (ECB), 'creative leadership behavior' (CL), and 'enhancing creative leadership behavior' (ECL): mean 3.008 – 3.541, scale of 1 to 4. The outcome 'course satisfaction' (CS) scored 100% *(very) satisfied*, and 'working on learned skills after course' (WS) scored 100% *sometimes or often*. The mean of the variable 'facilitating design meetings per month after course' (FM) is 0.325 times per month. These learning outcomes can be considered to be *good* based on the 5-point Likert scale (i.e. poor, fair, average, good and excellent).
Table 5.6 demonstrates the coherence between the learning outcomes and the set of design principles. This table shows that the number of realized matches is 345. In the table, the keywords were grouped per design principle, so that the number of possible matches was reduced to 375 and realized matches was 207 (Mean 13.8, Max 24 and Min 7). The design principles matched with the 6 questions on 'knowledge of creative and collaborative thinking' (CT) 59 of 90 (65.5%), with the 12 questions on 'Creative behavior' (CB) 51 of 180 (28.3%), and with the 7 questions on 'creative leadership behavior' (CL) 98 of 105 (93.3%). The design principle 'constantly change conditions' had the highest number of matches (36 times) and 'choosing suitable methods' had the lowest (7 times). Table 5.6 shows that the coherence between the descriptions of the survey questions and the learning outcomes can be qualified as *fair* based on the 5-point Likert scale (i.e. poor, fair, average, good and excellent).

Table 5.6. Matching 15 design principles' keywords with the text of the survey questions.

SURVEY QUESTIONS		DESIGN PRINCIPLES: Produce an accurate meeting scenario	Invite a variety of participants	Explain method in simple terms	Have participants listen to each other	Set a reluctant participant to work	Give rhythm to activities	Reformulate the question	Don't adhere strictly to the plan	Continuously change the circumstances	Take participants out of their comfort zone	Make the participants do the work	Let the hands do the thinking	Alternate between strict and relaxed	End with perspective	Choose the most suitable method
KNOWLEDGE OF CREATIVE AND COLLABORATIVE THINKING	Creative and collaborative thinking (1-2)	1	4	2	5	1	2	0	3	4	2	2	2	1	1	0
	Rhythm (3)	3	2	3	2	1	9	4	1	1	1	2	0	2	1	0
	Techniques (4-8)	0	1	1	1	1	3	0	2	0	1	0	1	0	2	0
	Creative thinking skills (9-11)	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1
	Idea processing (12-15)	1	2	0	2	0	0	1	0	1	0	1	0	2	0	0
	Preparation (16)	3	1	2	1	1	1	1	1	1	1	1	0	3	1	0
CREATIIVE BEHAVIOR	I achieve targets	1	0	0	0	0	0	0	1	1	1	0	0	0	0	1
	I generate ideas	0	1	0	0	0	0	0	2	1	2	0	1	1	0	0
	I generate technologies	0	1	0	0	0	0	0	2	1	2	0	1	0	0	0
	I improve quality	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
	I'm a source of ideas	0	1	2	0	0	0	0	1	1	1	0	1	0	0	0
	I promote ideas	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0
	I'm creative	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	I implement techniques	1	1	1	0	0	1	0	2	1	2	0	1	0	0	1
	I have new ideas	0	1	0	0	0	0	0	2	1	2	0	1	0	0	0
	I propose new ideas	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0
	I have innovative visions	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	I introduce working methods	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0
CREATIVE LEADERSHIP	Mobilize and unite	3	1	2	1	1	1	1	1	2	2	1	0	1	2	1
	Synthesize and structure	2	3	2	3	1	1	2	3	3	2	1	1	1	2	0
	Decision-making	1	1	2	2	2	1	1	0	2	1	1	0	1	2	0
	Share and delegate	2	2	3	3	2	1	1	1	2	3	2	1	2	2	1
	Overview and readjust	2	4	3	3	2	1	1	1	2	2	3	1	2	2	1
	Coach	1	1	2	1	1	1	1	1	2	1	1	0	1	2	0
	Responsibility	3	2	4	1	2	2	2	1	2	4	1	1	2	4	1

Brazil beta test
The ideas of the design principles were published previously in order to invite users to experiment with them. During vision design sessions, some design principles were applied in a bachelor's degree course for Fashion Design at the Federal University of Juiz de Fora in Brazil. In a survey conducted after the course, the students gave the course a 3.75 on a scale of one to five (SD 1.28, N = 8), which means the students were satisfied with the course. Initially there was resistance from the students, but this disappeared during the practical exercises. The lecturers found that the results achieved by using the design principles were better than the designs sketched on paper. Pinheiro and Queiroz (2013) concluded that it is likely three of the stated design principles used in these vision design meetings led to *improved results* compared to when these principles were not used. Their article was published in Brazilian Portuguese but the English translation can be found in Appendix E.

5.4.3. Assessing the validity of the evaluation and qualification results
This validity assessment (i) consists of identifying the plausible rivals and (ii) explaining how these rivals have been disqualified as much as possible. The craft rivals will be discussed first, followed by the real-life rivals.

The craft rivals
The first type of craft rival is the *null hypotheses,* which states that the results can be explained by coincidence. This rival has been disqualified as much as possible by conducting the field trial six times and by inviting all participants to complete the questionnaire. The scales used to measure creative (leadership) behavior have been proven and statistical tests were carried out to determine the Cronbach's alpha. See Table 5.2. Only the score for the creative leadership behavior measurement was lower than the Cronbach's alpha standard of 0.7. The omission of one or more items did not improve the Cronbach's alpha at all. A reason for the low alpha could be that the descriptions of the questions on the test were modified. See Appendix C for this modification.

The second type of craft rival is *threats to the internal validity.* There are several craft rivals in the category; each of these will be successively described hereunder.

To disqualify the rival referred to as 'history'—i.e. *the effect may be the result of a different event that took place between the pre- and post-measurements*—the course participants were explicitly asked to what extent the course had contributed to all of the specific items regarding creative (leadership) behavior. This additional question also disqualified the rival referred to as 'natural development and growth'—*i.e. course participants become smarter, cleverer, more experienced, etc. between the pre- and post-measurements*.

The rival 'testing'—i.e *the effect of taking the same test again*— has been disqualified by having the course participants complete the questionnaire only once.

The rival 'instrumentation'—i.e. *variance of the measurement instruments between the pre- and the post-measurements*— has been disqualified by conducting only one post-measurement, whereby 32 course participants completed the questionnaire in the presence of the researcher and 12 emailed their completed questionnaires. Of the five learning outcomes that were scored, two differed significantly for the group that responded via email compared to the group that responded in person. In the presence of the researcher, the course participants scored higher on 'knowledge of creative and collaborative thinking' (CT) (7.47 (N = 32) compared to 6.25 (N = 12)) and scored higher on 'enhancing creative leadership behavior' (ECL) (3.460 (N = 32) compared to 3.202 (N = 12)).

The rival 'statistical regression'—*i.e. when groups were selected for their extreme scores, this led to a distortion of the mean*—has been disqualified by comparing the current results to the previous measurement of the 'creative behavior' of 43 BAM employees made by Van Luijtelaar (2010)E. The mean score for 'creative behavior' (CB) for these employees was 3.2344 (SD 0.68436) and for the course participants the score after the course was 3.5407 (SD 0.36568). The performance of a t-test indicated that there was a significant difference between these two groups (Sig. = 0.012).

The rival 'distortion through selection' has been disqualified because all participants of the course were invited to participate in the survey. There was no selection.

The rival 'loss of respondents' has also been mostly disqualified. The response rate of course participants in completing the questionnaire was 78.6%. A number of participants were not reachable because they moved to BAM International or started working for another company.

The third type of a craft rival is *threats to the external validity,* which has been disqualified by presenting the results of the survey to some of the course participants. The results have been endorsed by the course participants.

The last type of a craft rival is *bias on the part of the researcher*. The course was largely designed by the primary researcher and conducted in collaboration with a professional trainer. This trainer also conducted the intake interviews so that the course program details could be amended to suit the existing skills of the course participants. The trainer also provided feedback on the design of the questionnaire. This collaboration limited any bias on the part of the researcher.

The real-life rivals

The rival 'direct or mixed'—i.e. *the assertion that a different intervention is partly responsible for the result* —has been disqualified based on contact with participants after the course. The researcher was present when 32 of the 44 questionnaires were completed and gained insight into which other interventions took place.

For example, the researcher took part in design meetings organized by former course participants and network meetings in which the trainers gave additional training. It was found that participating in these meetings boosted the participant's motivation to learn during the course.

The 'implementation rival'—i.e. *the assertion that the implementation method of the intervention is responsible for the result*—has been disqualified because well-established measurements were used for measuring the creative (leadership) behavior.

The threat of the '*rival theory*'—i.e. *the choice of the research approach influences the conclusions relating to the validity*—has been minimized because the approach *design science research* is the most suitable for this study, as was argued in Chapter 1.

The 'super rival'— *i.e. the assertion that both the studied intervention and the attained results are part of a much larger and more powerful process that is responsible for the result*— is present; a number of course participants worked in an environment in which the learned competences could not be applied or where the manager did not provide any space for such opportunities. As a rule, it was advised during the course that the skills be used in personal conversations and in self-initiated progress dialogue.

The 'social rival'—i.e. *the assertion that a dominant social political or economic situation is responsible for the result*—has been excluded by asking the participants during the survey to what extent the course had affected their creative (leadership) behavior.

5.5. Summary Results

The results of the first sub-topic, *Evaluating the creativity facilitation course*, show that the measurements of the learning outcomes can be considered to be *good*. See Section 5.4.2. When evaluating the course for further research, a pre-measurement of the learning outcomes must be carried out. In addition, attention must be given to the survey questions to measure 'creative leadership behavior' to enhance the Cronbach's alpha.

The results of the second sub-topic, *Qualifying the implementation of the set of design principles,* are the demonstrated coherence and the results of the Brazil course's beta test. The coherence can be considered to be *fair*. By re-composing the survey questions for the variable 'knowledge of creative and collaborative thinking' (CT), the focus must be placed on the knowledge about the set of design principles. The table also shows that the coherence between the design principles and the survey question 'creative leadership' was higher than the questions about 'knowledge of creative and collaborative thinking', and much higher than the questions about 'creative behavior'. The Brazil beta test showed that it is likely that three of the design principles used in these vision design meetings led to *improved results* compared to when these principles were not used.

The validity assessment summed up a series of activities that could be used to disqualify the rivals. The *plausible rival explanations* method has made the rivals visible and has provided insight into the activities that have been performed to try to disqualify them; however, the use of the method did not lead to perfectly reliable conclusions but increased the transparency of the research. This transparency is one of the requirements of a pragmatic validation.

Considering the three above-mentioned judgments and the result of the validity assessment, it seems likely that the set of design principles is a useful and effective guide that facilitators can use to plan, organize and conduct design meetings in the AEC sector.

The above statement, "Convention, a type of memory, is the greatest obstacle to enjoying life and art" by Piet Mondriaan can be seen in the hall of Eindhoven railway station. More than 35 years, I arrived at this station for an internship, to study and to work.

Chapter 6
Conclusions, reflection and discussion

6.1. Introduction

The AEC sector clearly needs to improve its methods of creative and collaborative working during meetings in which the professionals are already having difficulty managing the current developments. In the first chapter of this study, a central research objective was formulated to solve this problem in the AEC sector. In Chapter 2, a method was introduced that would allow the central research objective to be achieved, and Chapters 3, 4, and 5 reported on the results of the main research topics.

The present chapter will provide the conclusions of the central research topic: *Developing a creativity facilitating course based on validated design principles,* by considering the creativity facilitation course, the set of design principles and the research methods. Finally, other results will briefly be mentioned and a final reflection will be made on the study.

6.2. Creativity facilitation course

The course offers a solution to the field problem. This section describes the course and indicates which needs it fulfills. Subsequently, it will explain the relation between the sub-aims of the course and the field problem. The current developments in the AEC sector will also be described in this section, and the additions of the existing step models and process frames by the design principles will be mentioned. This discussion of the field problem, current developments, and existing step models and process frames will provide evidence that supports the conclusion that the course is effective and does 'work' according to the criterion mentioned by Van Aken and Van Fenema (2014). Finally, the applicability of the course will be demonstrated.

6.2.1. Solution to the field problem

The creativity facilitation course, which is based on a set of validated design principles, offers a solution to the following field problem: *Creative and collaborative working during face-to-face design meetings in the AEC sector is not planned, organized or conducted with adequate knowledge or skills* (See Chapter 1.3). This solution is a means to enhance creative and collaborative working, which is necessary to respond to current developments in the AEC sector, as described in Chapter 1.2.

The creativity facilitation course also fulfills the needs of "structuring face-to-face meetings" and "guidelines for trained facilitators to enhance group creativity" that were identified in the literature and described in Chapter 1.5.2. To fulfill these needs, the course teaches the design manager to apply the design principles to 'produce an accurate meeting scenario' and 'give rhythm to activities'.

A summary of the creativity facilitation course based on a set of design principles is presented in a leaflet; see Figure 6.1 (depicted from Figure 4.16). The course program that has been implemented is shown in Table 4.15.

The creativity facilitation course based on Handstorm principles

This course teaches professionals in the AEC sector how to plan, organize and conduct creative face-to-face meetings by using a set of design principles.
The focus of the course is (i) oriented to the AEC-sector, (ii) about involved facilitation, (iii) about stimulating cooperative learning, (iv) about using varied skills and intelligences, (v) about creating an open culture, and (vi) about consulting a set of design principles.

Set of design principles that forms the basis of the course
The set consists of 15 design principles that can be briefly described as follows: *plan a detailed meeting plan, invite a variety of participants, explain working methods in a simple way, have participants listen to each other, put a reluctant participant to work, create rhythm in activities, reformulate the question, don't be afraid to deviate from your meeting plan, continually change the circumstances, take participants out of their comfort zone, let the participants do the work, let the hands do the thinking, alternate between strict and lenient, close the meeting with perspective, choose the working method most appropriate for your meeting.*

What you learn
After the course, the participant will know what creative and collaborative thinking is and will have enhanced his/her creative behavior and creative leadership.

For whom
For professionals in the AEC sector who are working as a director, manager, supervisor or engineer with a degree from a university or university of applied sciences, primarily in technical sciences.

Themes
The following themes will be discussed: creative thinking in a group, creative skills and techniques, planning a creative meeting by making a scenario, using the design principles, the group dynamic aspects, the role of the facilitator, and using tools.

Didactic methods
The learning approach is primarily doing exercises. During the course, the participants will plan and conduct a creative meeting four times. Shortly after each meeting participants reflect on the scenario and on the facilitation process. The maximum number of participants is 10.

Trainers
The course will be presented by two trainers: one with a background in construction management and engineering, and creative and collaborative working, and another with a background in group dynamics and personal development.

Study load
The study activities will take up 3.5 days and homework will consist of studying books and facilitating a design meeting at the student's place of employment.

Figure 6.1. Creativity facilitation course leaflet for AEC professionals (depicted from Figure 4.16).

6.2.2. Reflection

Course sub-aims

The main aim of the creativity facilitation course, namely to *teach professionals to better plan, organize, and conduct face-to-face design meetings in the AEC sector,* is divided into six sub-aims. These sub-aims will be used to clarify how a learning objective enhances the skills of the professional, so that he/she can contribute to solving the field problem and can react to the current developments in the AEC sector.

The first sub-aim, *stimulating cooperative learning*, is simple to incorporate using the learning objective 'the course participants can select and facilitate methods in such a way that people in the meeting learn from each other'. This skill stimulates collaboration between designers and users as they discuss how they should explore the solution space during the tender, design, production and maintenance phases.

The second sub-aim, *using varied skills and intelligence*, corresponds with the learning objective 'the course participants can use the didactic methods that make optimal use of the strengths of the people in the meeting'. The participants of a meeting have particular habits and individual cultures and are a source for creating new ideas. The professional learns how to use (serious) play to stimulate such creative and collaborative working. The creativity technique 'constructing metaphoric objects' is a good example of stimulating collaborative working. See Table 4.12.

The third sub-aim, *oriented to the AEC sector,* teaches the professional how to facilitate creative meetings, where e.g. performance tenders call for a unique approach. The learning objective 'the course participants can identify different team roles during a design meeting and can utilize the strengths of the people in the design meeting' cultivates the ability to identify the needs and the values of the client and user. A didactic method used in the course to work on this learning objective was role playing with the roles of client and user.

For the fourth sub-aim, *involved facilitation,* the facilitator must make the participants privy to the problem and the solution. The learning objective is 'the course participants can maintain the basic rhythm of the design meeting so that the people taking part are continually challenged'. This basic rhythm especially involves engaging with the problem and reformulating the question. A didactic method used in the course to work on this sub-aim was having the course participants plan a design meeting based on the aforementioned rhythm by producing and executing a meeting scenario. Course participants who facilitated meetings as exercises were generally focused on getting their solution accepted and not on facilitating a solution that had been developed by the participants. When providing feedback on such an exercise, trainers mentioned that they had to address this problem many times.

The fifth sub-aim, *creating an open culture,* involves the key values of transparency, reflection and respect. At the beginning of the meeting, an agenda is presented and at the conclusion the students and trainers will reflect on the process. These skills are learned during the course. Transparency and reflection enhance the participants' ability to benefit from each other's knowledge, skills and experience.

The sixth sub-aim, *consulting a set of design principles,* has been incorporated into the course by deriving the learning objectives from the design principles, so that the course participants can enhance their ability to consult the design principles. The chosen research approach demands that the course has been produced through the application of appropriate theoretical knowledge and methods.

Set of design principles

The set of design principles includes elements of the step models and process frames summed up in Chapter 1.4.1, such as the meeting phases depicted by COCD: starting, diverging and converging; creating a open culture with the MHP method; and the difference between the problem owner and session leader with *FF Brainstormen*.

Some design principles are an addition on the existing step models and process frames. These additions will be described.

A powerful design principle is *let the hands do the thinking*. During one of the experiments in this study, a workshop with students was facilitated in which no written words could be used and the students could only communicate with hand-drawn sketches. A part of the workshop was to learn to express thoughts and emotions with sketches. After the workshop, many of the participants were able to make such sketches and tell stories for clarification. This design principle is powerful because participants of design meetings in the AEC sector are mostly talented and educated in eliciting and communicating ideas with the help of sketches.

A challenging design principle is *give rhythm to activities*. By alternating, diverging and converging activities, the energy in a group can be enhanced. This works like a heart, which presses and releases to generate a flow of energy. Maintaining the energy in a group is also related to the flow theory from Csíkszentmihályi (1990): use appropriate activities or interventions to balance the degree of difficulty of a task and the level of skills of the participants. This design principle is challenging because it asks for a certain degree of empathy by the facilitator.

The design principle *produce an accurate meeting scenario* involves the tasks of planning and organizing a design meeting and writing down the activities as a scenario. This design principle compels the facilitator to reflect more on the meeting process and less on achieving personal goals. When methods no longer work, diverge from the scenario and choose another activity. A well-prepared scenario helps to improvise the change. This change leads to the renewed motivation of the group, because changing frames can motivate participants again. During design meetings in the IFD case (See Chapter 3), no scenario was produced; the project leader used the minutes of the last meeting as the agenda of the current meeting. Therefore, no attention was given to the aim of the meeting or to which working methods were suitable. Thus, an accurate meeting scenario is essential.

The design principle *set a reluctant participant to work* solves a real problem that may be encountered by the facilitator. During workshops with students, the participants often become more reluctant when the lecturer focuses on theory; interactive didactic methods can decrease such reluctant behavior. For instance, letting the reluctant participants summarize their findings, draw their ideas on a poster or work alone for a period of time are very suitable interventions. In many cases, the reluctant participant becomes serious when he/she is concerned about the agenda.

Participants of a design meeting are not used to working with creativity techniques. The design principle *explain methods in simple terms* will stimulate the facilitator to devise an exercise with simple examples before starting the serious technique. During the course, this was one of the points of interest that the trainers often mentioned.

Finally, the set of design principles should be seen as a set of interconnected principles that strengthen each other. Because they were validated as a set, the 15 design principles have been labeled with the trade name Handstorm®[8] principles, referring to the design principle 'Let the hands do the thinking'. The name Handstorm® principles was chosen to indicate that these principles not only involve the use of both the left and right sides of the brain, but also the use of the rest of the body, employing one's hands, taste buds, gestures, feelings, voice, and more. Designs are typically made with the help of artifacts, images, photos, language, analogies, stories, boundary objects, natural materials, writing implements, paper, and so forth. Handstorm (working with materials, tools, constructions and machines) can be considered an enrichment of brainstorming which is a cognitive and intellectual process.

6.2.3. Applicability

As of 2015, the course has been implemented 11 times. The first six times it was evaluated. The course was given to a homogenous group, which was composed mainly of men who had trained as engineers, worked for the same construction firm and who had already been working in public-private-partnership tendering for some time. At least for these types of participants the creativity facilitation course is applicable.

The creativity facilitation course continues to be applicable for the professionals working for the BAM Group, and remains a regular course of the BAM Business School. The reason for this continuation could be that the BAM Group needs the skills taught in this course, in order to teach their professionals to prepare and operate performance-oriented tenders. In 2014, the subsidiary company BAM PPP (Public Private Partnership) won six projects, with a hit rate of 50%, which represents approximately one billion euro of construction revenues (BAM Group, 2015).

The course is applicable for Dutch building companies that are confronted with inadequate knowledge and skills for creative and collaborative working. A significant part of the participants of the course (27.3% by BAM PPP and Vitaal Zorgvast) are employed by subsidiary companies in which many meetings take place with participants from outside of BAM. These course participants found that what they learned was beneficial. There is no reason to believe that the creativity facilitation course is not broader applicable outside the Dutch AEC sector.

6.3. Set of design principles and research methods

The study delivers a validated set of design principles for the scientific domains of building design management and small group creativity. Moreover, it delivers also a research perspective for meetings, a procedure for developing design principles, and a survey to measure learning outcomes. Experience is acquired with the application of the research-

[8] In 1990 Stephen Nachmanovitch used the term 'Handstorming' in his book *Free Play: Improvisation in Life and Art*. According to Nachmanovitch, brainstorming is a social form of automatic writing: "a group of people sit together and blast out ideas without fear of shame or foolishness. The therapeutic form is free association, drilling down into preconscious and unconscious material and letting it emerge in a free-form way. In the visual arts there is an automatic drawing- let's call it handstorming" (Nachmanovitch, 1990).

design-development cycle and with the plausible rival explanations method. These scientific results are discussed with regard to their reliability, validity, and generalizability. Finally, the limitations of the results are discussed, and suggestions for further research are made.

6.3.1. Scientific results

The scientific results of this research are a set of design principles and some research methods, such as a model to describe meeting activities, a procedure to develop design principles and a survey to measure learning outcomes. These scientific results and the experiences with the application of the research-design-development cycle and the plausible rival explanations method will be described.

Set of design principles

The set of design principles is suitable for developing creativity facilitation courses and fulfills the needs found in the literature of the domains *build design management* and *small group creativity* which have been described in Chapter 1.5. Eric F. Rietzschel (2015) stated that stimulating creativity, structure and restrictions can be helpful, because they decrease the task complexity. A facilitator using the set of design principles can be aware the needs of the participants during a design meeting, such as more structure or more autonomy. Paulus et al. (2012) have stated that face-to-face design meetings should be more structured and the appropriate guidelines should be used by trained facilitators to enhance group creativity. The set of design principles contributes to fulfilling this need. Chapter 1.5.3 describes several needs that were identified by the researcher. The devised set of design principles has become a suitable guide for organizing more effective design meetings. During the course, the students learn that initiating and leading multi-disciplinary collaboration is a skill that is learned by doing.

The set of design principles can also be used for developing other design solutions, such as workshops, lectures, sessions, symposia, meetings with master students, courses, creativity techniques, simulation games, and so forth. See Section 6.4 for two examples.

Research methods

Based on the Structured Analysis and Design Technique (SADT), a model was developed to describe the activities within a meeting. The model consists of five parameters: ‘aim’, ‘participants’, ‘tools’, ‘control’ and ‘outcomes’, and these parameters have been used as assessment criteria to find mechanisms in Ph.D. studies. Three of the intervention parameters, ‘control’, ‘participants’ and ‘tools’, are incorporated into the design principles. See Table 5.5. The model could further be used to describe and plan meetings as a hierarchy of activities.

A procedure has been devised to develop design principles by synthesizing successful interventions and mechanisms. The successful interventions (WHAT) were drawn from experiments that have been evaluated and described in scientific and professional articles. The mechanisms (WHY) were drawn from Ph.D. studies. This procedure demands syntax for a successful intervention (an intervention that has created the desired results) and an assertion for a mechanism (subject-predicate-object). The reasoning is then as follows: WHAT + WHY → Design principles, described according the CIMO logic.

A survey has been created to measure the learning outcomes of a creativity facilitation course. The method of measuring the variable ‘knowledge of creative and collaborative thinking’ has been devised by the researcher. The scale of ‘creative leadership behavior’ is a modification of a scale from the literature.

The research-design-development cycle has proven to be very suitable for designing this research. The following research activities are derived from this cycle: (i) developing a set of design principles as a scientific basis; (ii) developing a course as a solution to the field problem, and based on this set of design principles; (iii) implementing the course in practice; and, finally, (iv) evaluating the course. Ultimately, the set of design principles was validated so that it can be used for other solutions. This research-design-development cycle is very suitable for researchers who are working on a solution to a field problem (such as producing or devising a *technological design*) and for those who also want to generate new knowledge at the same time.

The plausible rival explanations method, according to R.K. Yin (2003), can be used to analyze the data and enhance the validity and reliability of the evaluation results. See Chapter 5.3.3. The procedure consists of identifying the plausible rivals and then explaining how these rivals can be disqualified. The method covers a wide range of validity aspects and makes them visible, but it did not lead to excellent, reliable conclusions. The method will be more valuable when it is used during the design of the practice-based research.

6.3.2. Discussion

In this section the quality of the scientific results will be discussed regarding reliability, validity and generalizability.

Reliability

The researcher has striven to achieve maximum practical relevance and the greatest possible methodical thoroughness which is necessary for a design science research approach. The researcher has chosen to implement the course at a construction firm as part of the existing educational program in order to achieve the maximum practical relevance. The greatest possible methodical thoroughness has been achieved by implementing the course six times, by using existing knowledge, by initiating a beta test, and by evaluating the course on the ‘indicative’ level.

The research was conducted within the researcher’s professional practice. Such commitment leads to comprehensive research, but it can sometimes also lead to tunnel vision. However, collaborating with other researchers and publishing results in symposia proceedings between 1990 and 2015 ensured continuous reflection.

Validity

To validate the set of design principles, a pragmatic approach was chosen because the interventions, the system of interest, and the desired results were too complex to conduct a causal research. Implementing a course in practice is complex and causal research requires the researcher to make concessions regarding practical relevance.

Validation requires testing in practice and to determine whether the set of design principles works by evaluation research.

The plausible rival explanations method has been used to enhance the validity of the results. A rival in this study was the self-rating question, which can be disqualified by further research by doing a pre-measurement. When designing the research, this method can be useful for identifying the rivals, without having to make too many concessions regarding the practical relevance.

A data triangulation – the use of different samples, spaces and persons – carried out by initiating a beta test, has enhanced the generic applicability of the set of design principles. Lecturers of the bachelor's degree course for Fashion Design at the Federal University of Juiz de Fora in Brazil used some of the design principles to plan, organize and conduct a vision design session. The lecturers evaluated the course with a questionnaire that was created by the researcher of this study and which was published in conference proceedings (Van Gassel, 2005). This evaluation indicates that the students were satisfied with the results of the course. Initially there was resistance from the students, but this disappeared during the practical exercise. It seems likely that three of the stated design principles used in vision design meetings led to improved results compared to when these principles were not used. The lecturers published the results in a scientific article (Pinheiro & Queiroz, 2013). See Appendix E for the English translation of this article. This beta test shows that the use of design principles works for the Brazil course.

A methodological triangulation – the use of two or more research strategies, in this case desk research, case study, six experiments and survey research – has ensured the greatest possible methodical thoroughness.

Generalizability

The set of design principles has been generically formulated so that the set can be a robust basis for attractive and broad applications for creative and collaborative working.

In particular, the set of design principles for creative and collaborative working is generic enough to be used for design courses at a university. As mentioned above, certain design principles were used to develop a bachelor's degree course in fashion design at the Federal University of Juiz de Fora. The design principles have also been used to compose curricula for three courses at the Eindhoven University of Technology. See Tables 5.10, 5.11 and 5.12. There is no reason to believe that the set of design principles for creative and collaborative working is not applicable for other university design courses.

The design principles were also used to develop two creativity techniques: 'Constructing a platform' and 'Constructing metaphoric objects'. See Section 6.4. These two creativity techniques were implemented and evaluated in proceedings of symposia.

6.3.3. Limitations and further research

To determine the effectiveness of the interventions, four levels of evaluation are available: descriptive, theoretical, indicative and causal. See Chapter 2.3. 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 there is now more data available regarding the impact of the interventions on the outcomes.

Course member experiences 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 what they had learned during the course. This form of self-assessment is less objective weaker than taking measurements before and after training. By further research it might be better to measure the knowledge and behaviors 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 behavior' 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 enhance the coherence.

The design principles were developed through a synthesis of research findings, which were based on 28 doctoral dissertations, and on professional practices, which were based on 14 experiments. Most of the doctoral dissertations were published by Dutch universities, but the research was organized internationally. The experiments were carried out at Dutch firms and at the Eindhoven University of Technology. Further research can consider more reported experiments in the synthesizing process.

The development of a research perspective, which involved finding meeting parameters to describe the research design principles for the course, is based on a sample of 35 meetings that took place during the IFD innovation project. The parameter of 'participants' has not been solidified within this IFD case study, because the project was so specific that it did not attract diverse participants. Earlier research, based on a literature survey and three case studies, showed that the parameter 'participants' is part of the *architectural meeting model* (Van Gassel et al., 2009). By further research, the meeting model can be used to find correlations between the values of the parameters and to describe and plan meetings as a hierarchy of activities.

The design principles have been used to develop a creativity facilitation course for the AEC sector in the Netherlands. After implementing and evaluating this course, the design principles were validated. The design principles were also used to develop course at a university in Brazil. Further research should validate a set of design principles for other sectors, such as the ICT sector, healthcare, and government. Moreover, a set of design principles should be validated for meetings in which new (industrial) policy is created, introduced and maintained. Increasingly, the design of new products and processes is taking place in an international context. Therefore, it might be worthwhile to research the extent to which the design principles can be used in countries other than the Netherlands and Brazil.

The last suggestion is that future research should use a variant of the set of design principles to stimulate the acquisition of some 21st century skills, such as cooperation, knowledge building, problem solving, creativity, and working systematically. It might be worthwhile to research how working with the developed set of design principles could be integrated into education programs for engineers and designers to enhance these 21st century skills.

6.4. Other results

This study delivered work methods, experiences and knowledge that were not anticipated by the research design. These results are described below.

One result is the course assignment facilitating a meeting. First, the course participant makes an agenda, organizes the logistics and then does the facilitation. During the preparation for this assignment, the course participants were not aware of how difficult it would be to facilitate such a meeting, and the preparation was not taken very seriously. When problems arose during the facilitation, the trainers gave them direct feedback and suggestions for how to continue. It was not until after the assignment that the participants were aware of how difficult it is to facilitate without good preparation. During the survey, the participants stated that this assignment was eye-opening for them.

Another finding is the importance of the use of an energizer; this is a (didactic) method that is used to increase the energy of the participants. This can be done by playing, for instance, a physical game requiring competition between two groups. For example, the facilitator can suggest a competition to see which group can cross a certain distance without touching the floor. Facilitators are often afraid that the participants will find this method childish, but in practice, this is rarely the case. Participants are more willing to participate if the energizer suits them and if the facilitator is enthusiastic. If the facilitator shows any uncertainty, the energizer will not work.

Course participants were clearly engaging in the learning outcome 'creative behavior' during their presentations of their facilitating experiences in their work environments. A PowerPoint presentation was not permitted; the assignment was to devise a unique type of presentation. Participants used the following diverse types of creativity skills to distinguish themselves: role-playing, short theatrical skits, newspaper reports, TV and radio interviews, big objects as a metaphor, large mood boards, interactive discussions, etc. This demonstrates that setting well-chosen restrictions on assignments can enhance the level of creativity.

During the survey, a course participant came to the conclusion that he was not competent as a creative facilitator, and asked someone else to take over his job to ensure that the design meeting would be facilitated in the way he had learned. This scenario demonstrates that enhancing creative (leadership) behavior is not the ultimate goal, but that a notion of the specific methods is sufficient to improve creative and collaborative working.

The learning outcomes 'facilitating creative meetings per month after the course' and 'working on learned skills after the course' measure the extent to which the course member will implement the learned skills in practice. These two learning outcomes are very important and are essential to the development of the course. An in-depth analysis of the results of this study shows that a correlation of 0.550 was found between 'working on learned skills after course' (WS) and 'course satisfaction' (CS); there was a correlation of 0.518 between 'facilitating creative meetings per month after course' (FM) and 'working on learned skills after course' (WS) (Pearson correlation test; Sig 0.05 level (2-tailed)). These results can be used, for example, to develop suitable didactic methods to stimulate the implementation of the learned skills in the working environments of the course members.

A web portal was provided by the BAM Group, which supports former course participants in planning, organizing and conducting creative meetings**.** Two simulation games 'Partner selection' and 'Creative supply and demand' were developed for the experiments in this study and are described in more detail in Tables 4.12 and 4.13.

Two creativity techniques, 'Constructing a platform' and 'Constructing metaphoric objects', were developed for use during student workshops (See Tables 4.10 and 4.11).

The website www.handstorm.nl supports the practical use of the set of design principles, which is carried out under the trade name Handstorm®. The website also provides information about creativity techniques that were developed to support the use of the set of design principles, such as a public innovation market, a collection of manageable objects and a set of photographs. See Figure 6.2. Moreover, the website further explains the Handstorm concept.

A public innovation market. A symposium that features ten parallel creative workshops at a marketplace with a joint introduction and conclusion.

Collection of manageable objects. A bag containing all kinds of objects that can be used when introducing participants at a meeting or for giving rise to associations.

A set of photographs of sunflowers in all phases of growth and situations. To be used as a source of inspiration for various meeting activities.

Figure 6.2. Three design principles-based creativity techniques.

This study delivered a database containing the data from the survey that was conducted. The data can be used to generate new results, such as correlations between the variables to use them to enhance the quality of the course program. The database will be continuously available on 3TU Datacentrum (https://data.3tu.nl/).

6.5. Final reflection

This research is the result of many experiments that were conducted over a period of approximately twenty-five years. These experiments were conducted in various fields and were undertaken with a spirit of enthusiasm for gathering new knowledge in practice and documenting it methodologically. For the researcher, the design science research approach has been a methodology for developing a solution to a field problem, whereby the solution has been devised through the application of appropriate theoretical knowledge and methods.

Appendixes

Appendix A

The influence of automation and robotics on the performance construction[9]

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Abstract

In the decades to come, building production will concentrate in the metropolitan centres of the world due to the migration of the world's population to the major cities.

An improvement of the construction process in densely populated inner cities will be the task of the future. This focuses on performance management, construction engineering and construction management. New developments being discussed in this field are new design strategies, human machine technologies, employee safety, progress monitoring, distributed production information and Personal Digital Assistants (PDA's).
Keywords. Value creation; Performance management; Construction engineering; Construction management; Automation; Metropolis

1. Introduction

1.1. The building industry tomorrow

Changes in building production are essential if the world of construction is to improve. The changes are also necessary because the next few decades will see an enormous migration into the cities. The forecast is that in 2015, 55% of the world's population will live in the urban areas (see Fig, 1). These metropolises (densely populated inner cities with their agglomeration) impose their own requirements on construction management and production systems.

The following developments occur in the Western European construction industry. In Germany, building production has fallen by 35% in 5 years; in the Netherlands, by 15% in 3 years. In other countries on the European continent, the construction industry is hesitant. In Britain, the innovation process 'Rethinking Construction' was the prelude to a change in the system. The development of the 'chip' and the 'chip industry' has completely changed society as a whole. The developments in construction in recent decades can also be attributed to these changes.

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	1995	2015
Global and total	45%	55%
Developing countries	39%	50%
Industrial countries	75%	80%

→ Urbanisation

Fig. 1 Quota of urban population.

1.2. Changes in construction

The developments of the construction process are the result of a set of changing circumstances and conditions. These changes encourage developments of technologies to ensure the creation of a process that leads to improved performance for the client. These developments are based on an analysis of the Status Report issued in 2001 by the CIB Task Group TG27 'Human-Machine technologies for Construction Sites' [1] and of the Proceedings of the ISARC2003 Symposium; The Future Site [2].

In this analysis, automation in construction is addressed from the perspective of the performance of building projects serving the client and the environment.

- How can a connection between performance requirements and building production be established and improved through the use of automation in production?
- How can automation in construction engineering change the role of being a responsible partner in a changing world?
- How can construction management systems contribute to the improvement of production by automation?

When all building production is ultimately designed to lead to improved performance and a satisfied client, it is always difficult to keep sight of the overall picture and this final goal. Components develop and result in the required performance improvements. The overview in Fig. 2 shows the relationship between the various aspects of automation in construction. Construction management, construction engineering and performance management help the managers meet the needs of the client.

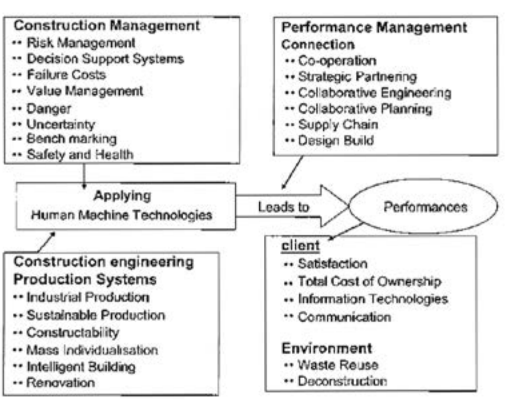

Fig. 2. Relationship between management, engineering and performance.

1.3. Examples of developments by automation

This paper looks at all three of the following aspects:

1. Performance management with a contribution about the development of new design ideas to meet client requirements in a different way.
2. Construction engineering with a contribution about the improvement of Human Machine Technologies, and about worker safety on the building site.
3. Construction management with contributions about monitoring project progress, about collection of the design and management information, and about support of the work floor manager with PDA's.

We will elaborate on these examples in Section 2.

2. Developments in automation in construction

2.1. Automation in performance management: the development of a new design strategy

1. The challenge when building in metropolitan inner cities is the development of production systems that go further than the Automation or robotizing of traditional activities on the building site which are normally carried out on site by the builders. A special form of Automation and Robotics is prefabrication. Prefabrication moves work away from the building site to a factory. For the builders, this is an enormous improvement because working conditions are checked and managed far more effectively. Production is moved to a certain extent but does not really change. However, production only really changes when new processes are developed. Functions are no longer assigned to the traditional building elements and are no longer carried out with those materials that people are used to.
2. Richard's contribution [3] draws an analogy with the development of the printed circuit board. Under the term 'reproduction', he describes an approach that leads to the redesign or reengineering of the construction process, "Reproduction implies innovative processes capable of short-cutting the long sequential operations of craftsmanship nature – i.e. capable of categorically simplifying the production, as notably illustrated by the analogy of Printing/the Printed-Circuit/the Printed Plumbing Core. Using performance criteria, in order to avoid a captive image from the past, one can identify promising options through the "Technology Matrix" (where processes interact with materials) and thereafter generate building system aiming at Reproduction". "Reproduction=priority to ideas rather than machinery". "Reproduction is the introduction of an innovative technology capable of simplifying the production of complex goods, of short-cutting long sequential operations. Therefore, achieving more substantial economies than mechanizing, automation or robotizing around the traditional construction methods". "Instead of investing straight into machinery, Reproduction is basically calling upon Research and Development for 'ideas' to generate a simplified process. Of course, Reproduction is not necessarily available as a downright option: it is often present together with some of the other degrees of industrialization".

3. Richard's contribution gives a whole new dimension to Fig. 2. Richard invites us to come up with new ideas. Not for improved production systems with or without the use of automation or robotization, but new ideas focusing on the performances that ultimately have to be achieved! All these new ideas will have to be generated by a combination of new designs, new forms and new materials that meet the requirements for building in a metropolis. This will create new production systems for the Future Site. Construction engineering for metropolises (Fig, 2) can undergo an enormous impulse. Automation creates the preconditions for following new avenues, which will bring us closer to the performance requirements of both client and metropolis. The opposite also applies: without automation, these new ideas cannot be developed into new processes.

2.2. Automation in construction engineering

2.2.1. The importance of human machine technologies

1. The safety regulations for building site work impose more and more restrictions on the loads workers are allowed to carry, prepare and apply using only the resources of their own body; but building contracts will expect an increasing amount of effort Take high-rise construction in metropolises and the attachment of wall cladding to these buildings, for example. Fitting heavy windowpanes or attaching wall panels with great precision is a challenge for the robotics industry to come up with new tools for this purpose.
2. The article by Choi et al. [7] presents a construction robot that is a hybrid type robot using pneumatic actuator and servomotor. "The hybrid type robot can be used in glass mounting on panel fixing. The hybrid type robot mechanism has a wide range of workspace and precision, and consists of a serial and parallel part. The pneumatic actuator has been widely used in industry site because of its low cost, compact high rate of power/weight arid reliability. The restricting factors preventing the use of pneumatic actuators for accurate control arise from highly non-linear dynamic properties such as air compressibility and friction effects, which combine to severely decrease time responsibility and positioning accuracy. The sliding mode controller is adequate to such as cylinder that is strong non-linear property. The developed construction robot with pneumatic actuator using the sliding mode controller used in the work of attaching the ceramic tile".
3. With this article, Choi et al. make a significant contribution to the development of human machine technologies (see Fig. 2) to help in heavy physical work in high-rise construction. In spite of all the modern production systems, much of the work will continue to be carried out on site. With regard to health, work speed and quality, mechanization of the work on site will remain an important goal for the successful development of major building assignments in our metropolises.

2.2.2. Worker safety on the building site

1. Complex high-rise construction work in a metropolis is an extremely risky undertaking. Complex logistics on the building site and in full inner cities require construction times to be kept to a minimum. This leads to highly compact building

processes and production systems that are sometimes unsafe and create many minor and major risks for the construction workers.

2. ‘The work described in the article of Abderra-him et al. [5] deals with the development of a particular security system, using both existing commercial technology and specially designed equipment The compulsory safety helmet required for all workers in construction sites is used as the base to accommodate miniature positioning and communication instruments. The position and ID of each worker is sampled periodically and sent via radio to a monitoring station, where the information is compared to a database containing the tasks and processes being performed in the site, According to this, workers and machines' positions are known in each instant and risk situations may be recognized immediately and therefore damage can be prevented. If certain workers and particular machinery and equipment elements are not supposed to be in certain locations for safety reasons, an automated system can be used to detect the situation and make the adequate decision to prevent a possible accident The proposed system is meant for modern construction systems where workers and automated/ semi-automated machines coexist”.
3. If we apply the article by Abderrahim et al. to Fig. 2, we see that it can make an important contribution to the minimization of risks. The instrument is designed to localize and detect the risks on site that cannot be prevented and to inform construction workers with warning signals of approaching danger (e.g. machines or crane loads) and to prevent people falling into openings in floors. By using databases, radio signaling and normal radio communication equipment automation (IT) can reduce the remaining risks on the building site which cannot be prevented by collaborative engineering by improving production systems. This makes it an important instrument in the final phase of risk management. The automated system adds value to the development of high-rise construction in metropolises by perfecting risk management.

2.3. Automation in construction management

2.3.1. Monitoring project progress

1. The complexity of building in a metropolis prompts the inclusion of performance indicators other than the traditional ones in a contract. A traditional contract gives the contractor the responsibility to supply products and to assemble them into a structure, and he is given a certain amount of time and money to do so. He is also expected to use the necessary capacity in terms of workers and machinery. In the traditional system, the contractor provides a design with drawings and calculations. The new construction assignment challenges the construction industry to carry out projects under new contract conditions. The newness of these contracts becomes apparent from performance indicators other than the traditional ones. The traditional performance indicators were primarily time, money and a detailed design with materials to be supplied. The new types of contract place responsibility more integrally on the contracting parties. This supplements the traditional performance indicators with new ones and creates the need for integral monitoring and checks of the project progress,

2. Navon's article [4] describes the options and developments using examples, "There are also briefly described together with the concept of measuring indirect parameters and converting them into the sought indicators. These are: (1) labor and earthmoving productivity, based on measuring the location of workers, or earth-moving equipment, at regular time intervals, (2) Progress, based on the above data, or data collected from a tower crane. (3) A comprehensive control of construction materials, starting by monitoring orders and purchasing up to the movement of the materials on site. (4) Monitoring the status of guard rails in order to prevent falls from heights".
3. If we apply Navon's contribution to Fig. *2,* we see that developments in the world of IT have a positive impact on the development of the possibilities of all kinds of aspects of construction management. They are the tools the contract partners can use to monitor the progress of complex contracts, The automated monitoring system adds value to the development of new types of contracts.
4. Yagi's article [9] stated that it is difficult to manage related information by using conventional mode. He proposed a new concept of 'Parts and Packets unified architecture'. Data or information related to a product are carried by product itself and can be handled to manage the whole system. It is a unified controller system, which operates parts and packets together.

2.3.2. Acquiring design and management information

1. Effective, tight management of projects during the development, design, execution and maintenance phases depends on a great deal of information. Without the right information, management is more like gambling and guessing than informed control. Construction in metropolises entails working with more partners than people are used to. These partners not only work together on the same project, they also need one another because they have their own projects which depend on one another. For example: flats above shops, offices with shops above a railway station. Various owners all have their own interest, backgrounds, needs, requirements, functional specifications, decision-making processes, etc. These aspects each generate their own specific information, so the manager who has to head up integrated projects in a metropolis is confronted by an immense flow of information. This information is not fixed, so the manager also has to rely on the quality of the information he is working with.
2. The article by Van Leeuwen et al. [8] discusses this problem and works out a proposal for not distributing this information but for sharing the various information sources. "The validity of information that a manager obtains from partners in a project can only be guaranteed by sharing of the information resources. This means that, rather than providing a copy of the information, the information is accessed at its source where the provider of the information has full control (and responsibility) over if". "To achieve such sharing of information, Van Leeuwen et al. propose a change of the paradigm 'distributed product information' from the supplier point of view to the consumer point of view. 'Distributed' no longer means 'sent to many

clients' but rather 'accessed at many providers'. Sharing distributed information resources has the potential to improve business processes in many ways:

- Avoiding unsolicited communication, the traffic of information is reduced, even if there is an increased amount of wanted traffic;
- It improves the validity of information, because it remains under control of the provider,
- It increases the quality of information, since it can answer a specific request or even result from a, possibly automated, dialogue;
- It helps to integrate business processes by keeping the relationships between the processes and their output data active",

3. In the article Van Leeuwen et al. provide an important insight into the development that ICT can stimulate possibilities for the exercise of construction management (see Fig. 2). With the right ICT tools, the manager (the client) has up-to-date information about all production systems, all risks and uncertainties and all design decisions and design options. This information enables him to follow how plans and production are developing on a daily basis (without lacking information) and how they ultimately meet the requirements of the client. It would probably be impossible to complete these complex construction projects in our metropolises without these kinds of ICT systems.

2.3.3. Support of the work floor manager with PDAs

1. These days, the on-site construction manager has serious problems having building production information processed efficiently, quickly and on time. On complex high-rise or underground construction projects in the metropolises, production information is not only processed to monitor progress and quality. A lot of data about the vicinity (groundwater level, stability of adjacent buildings, good traffic circulation) has to be processed every day. This is not only required to monitor progress, but also to prevent damage and ambient danger and to minimize risk.
2. The article by Kimoto et al [6]: "This paper reports a development of mobile computing system with PDA (Personal Digital Assistants) for construction managers on construction sites. First, this paper describes the aim, the concept based on End User Computing, and the essential element of the mobile system. This also shows the necessary functions for the mobile computing, and the concept of this computer-aided engineering system. Secondly, this paper describes the structure of the system and the outline of subsystems: Progress Monitoring System, Inspection System, Checklist and Reference System, and Position Check System".
3. To convert the work of the on-site construction manager into a substantive role and less that of an administrator of important information, it is essential to develop mobile computing systems in accordance with the proposal put forward by Kimoto et al. The reporting process is fully automated from the location in the project where the information is checked or available. Using a mobile computing system in combination with the distributed product information set out by Van Leeuwen et al, (see elsewhere in this volume) would cut out a whole series of administrative activities throughout the project and increase the efficiency of data management.

All data on the various construction management aspects in Fig. 2 are collected integrally and processed in real time. When this data is linked to pictures from, a digital camera and speech recognition in the future, it will be a real help to the construction manager, who will then have more time and attention for the actual content of the project.

3. Conclusion

The building assignment will focus on metropolises, which sets specific requirements for performance management, construction management and construction engineering.

Clients need individual treatment and a specific approach designed to solve their problem and meet their demands. They are less concerned in the size of the investment, but are becoming more and more interested in the total cost of ownership and life cycle cost. Nowadays, clients are less concerned with the structure itself. They pay more attention to its functional use, and this primarily stimulated by the use of information and communication technology in the projects.

Design strategies improve performance management.

Construction engineering is changed by the application of more industrial production, sustainable production, mass individualization, and intelligent building to improve constructability.

Construction management has to deal with safety and health, uncertainty and danger. Developments are taking place in risk management, value management and decision support systems supported by partnering collaborative design, supply chain management.

Better ICT tools provide the manager with better information raster by using distributed systems and PDAs.

These developments demonstrate that there is plenty of room for improvement in all process elements of construction projects in metropolises.

This underscores the economic importance of automation in construction. The ultimate goal is the value creation the structure is capable of.

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Appendix B

Questionnaire Chapter 3

Variables			Categories
Name	**Label**	**Question**	
DMeeting	Date of meeting	When was the meeting held?	DD-MM-YYYY
DMeasure	Date values were attached	When were the values attached?	DD-MM -YYYY
Plan	Plan	Was there a plan?	0 Not known 11 Yes 12 No
ScenarioP	Quality of plan	To what degree of precision were the activities in the plan described?	0 Not known 11 No plan 12 To a low degree 13 To a moderate degree 14 To a high degree
Location	Location	Where was the meeting held?	0 Not known 11 Company premises 12 Conference venue 13 Eindhoven University 14 Elsewhere
Aim	Aim of the meeting	What was the main aim of the meeting according to the plan?	0 Not known 11 To learn competences 12 To develop vision & mission 13 To develop strategies 14 To create ideas & concepts 15 To select solutions 16 To control construction process
MeetingT	Type of meeting	What type of meeting was scheduled?	0 Not known 11 Steering group 12 Research group 13 Design group 14 Construction group
ParticipantsN	Number of participants	How many participants attended the meeting?	X

Variables			Categories
Name	**Label**	**Question**	
ParticipantP	Professionalism of the participants	What was the professionalism of most of the participants?	0 Not known 11 Novice experts 12 Professionals
ParticipantE	Type of extra participants invited	What kind of extra participants were invited?	0 Not known 11 None 12 Experts 13 Clients
Control	Control of the meeting	Who chaired the meeting?	0 Not known 11 No specific person 12 Facilitator 13 Participant
Meeting room	Meeting room	What was the layout in the meeting room?	0 Not known 11 Traditional layout 12 Special layout
Collaboration	Collaboration	How did the participants collaborate with each other?	0 Not known 11 Plenary session 12 Plenary session and subgroups
DurationT	Duration of meeting	What was the maximum length of the meeting? The used unit is a "daily period" i.e. morning of afternoon.	0 Not known 11 1 daily period 12 2 daily periods 13 3 daily periods 14 > 3 daily periods
DurationB	Blocks in meeting	Into how many blocks was the meeting divided?	0 Not known 11 1 block 12 2 blocks 13 3 blocks 14 > 3 blocks
Activities	Special activities	Were special activities used to achieve a specific aim of the meeting?	0 Not known 11 No 12 Yes, but not many 13 Yes, a few 14 Yes, many

Variables			Categories
Name	**Label**	**Question**	
Tools	Tools	Were meeting tools used to explain thoughts?	0 Not known 11 No 12 Yes, to a small extent (whiteboard) 13 Yes, to a lesser extent (pictures or objects made beforehand) 14 Yes, to a considerable extent (collages made in the meeting)
Outcome	Minutes	What was the outcome regarding the aim of the meeting?	0 Not known 11 Hardly any outcome (no minutes) 12 Less good outcome (minutes were made) 13 Good outcome (detailed minutes were made) 14 Very good outcome (minutes and additional knowledge in extra documents)
Feedback	Feedback	Was there a reflection on the meeting's activity?	0 Not known 11 No 12 Yes
A0	Actions in meeting	How many collaborative actions were there in the meeting?	X
A1	Individual actions after meeting	How many individual actions were there after the meeting?	X
An	Collaborative actions after meeting	How many collaborative actions were there after the meeting?	X

Appendix C

Modified ‘Goossens and Verrue’ screenings test

	Description according to the screening test	Modified description
1	• I usually don’t succeed in making others enthusiastic about a specific project or aim. • It takes me a lot of effort to make others enthusiastic about a specific project or aim. • I can convince others about a specific project or aim • I can easily make others very enthusiastic about a specific project or aim.	When organizing a creative meeting • I usually don’t succeed in making others enthusiastic about taking part in a creative meeting. • It takes me a lot of effort to make others enthusiastic about taking part in a creative meeting. • I can convince others to take part in a creative meeting. • I can easily make others very enthusiastic about taking part in a creative meeting.
2	When a wide range of proposals are made during a group meeting: • I find it difficult to list the advantages and disadvantages of the various proposals. • I list the advantages and disadvantages so we can consider these as a group. • I pick out the strong elements from each proposal so that the group can work out a group proposal. • I summarize all ideas into a proposal that everyone can agree to.	When a wide range of proposals are made during a creative meeting: • I find it difficult to list the advantages and disadvantages of the various proposals. • I list the advantages and disadvantages so we can consider these as a group. • I pick out the strong elements from each proposal so that the group can work out a group proposal. • I summarize all ideas into a proposal that everyone can agree to.

	Description according to the screening test	Modified description
3	In a group session: • I stay in the background, as a result of which I have little influence on the decisions that are made. • I let the others know my opinion but my input remains limited. • I can clearly convey my opinion. In this way, I am able to contribute to the ultimate decision. • I take the lead, as a result of which I have a major influence on the decision that is made.	When facilitating a creative meeting: • I stay in the background, as a result of which I have little influence on progress. • I let others know my opinion about the level of progress. • I can clearly convey my opinion about the level of progress. • I take the initiative, as a result of which I have a major influence on progress.
4	When I coordinate a group project: • I try to personally take care of as much as I can so I'm sure it's done properly. • I more or less randomly delegate the tasks among the team participants. I have a strong tendency to control everything. • I delegate the tasks according to each person's capabilities. I have a tendency to control everything. • I delegate the responsibilities according to each person's capabilities. I keep an eye on everything in an appropriate manner.	When I lead a creative meeting: • I try to personally take care of as much as I can so I'm sure it's done properly. • I more or less randomly delegate the tasks among the course participants. I have a strong tendency to control everything. • I delegate the tasks according to each person's capabilities. I have a tendency to control everything. • I delegate the responsibilities according to each person's capabilities. I keep an eye on everything in an appropriate manner.
5	When working on a team assignment: • I focus on working out my part of the assignment. • I work out my part of the assignment and I try to gear this to the work of my team participants. • I work out my part of the assignment and I strive to gear all inputs to one another. I'll help my team colleagues if I'm asked. • I work out my part of the assignment and I ensure everything runs smoothly. I help and give guidance where necessary.	When I facilitate a creative meeting: • I focus on the individual input of the participants. • I gear the participants' individual inputs to one other. • I let the participants respond to each other's input. • I make sure that the participants inspire each other.

	Description according to the screening test	Modified description
6	When the enthusiasm diminishes in a group project: • I'm not the one who can revive it again. • I need someone to help me encourage the others again. • If no one else does anything, I try to revive the enthusiasm again. • I immediately take the lead to revive the enthusiasm again.	When the enthusiasm diminishes in a creative meeting: • I'm not the one who can revive it again. • I need someone to help me encourage the others again. • If no one else does anything, I try to revive the enthusiasm again. • I immediately take the lead to revive the enthusiasm again.
7	When working as part of a team: • I leave the responsibility to someone else. • I take the responsibility when I'm asked. • I will take the responsibility if no one else spontaneously offers do so. • I spontaneously take the responsibility in order to keep everything on the right track.	During a creative meeting: • I leave the responsibility to the participants. • I take the responsibility when the participants ask me to. • I'll take the responsibility if the participants don't. • I take responsibility for the process.

Appendix D

Course member's reactions

⇢ The course participants made the following additional comments on the questionnaire:

- Practice making the participants enthusiastic (1)
- Practice converging when using dream techniques (1)
- Need for additional training and/or a network of facilitators (2)
- Choosing a creativity technique for a specific problem continues to be difficult (5)
- Give more attention to the "How Can We" technique (7)
- Give more attention to the tail end of the creative session (7)
- List of creativity techniques to help make a better choice (10)
- Creativity techniques can also be used for progress dialogues and meetings (13)
- Creativity techniques are also suitable for analytical, policy and strategic sessions (14)
- Because the training didn't feel like training, what we learned was better embedded (15)
- It's still difficult to use the SIT technique (16)
- Make the SIT technique suitable for processes (17)
- Learning by doing; assignment feedback (19)
- Little group dynamics due to diverse capabilities of the participants (23)
- Enjoyable and useful training (24)
- Better dovetailing to private industrial sector (26)
- Training focused on technocrat/engineer and not on architect/visionary (27)
- Current job gives insufficient opportunity to use what has been learned (34)

⇢ The course participants made the following verbal comments.

- Get to know and respect participants better during creative meetings (1).
- By facilitating creative meetings, you convey a certain attitude (2).
- For the Supreme Council assignment, a creative meeting was held early on, when the architect was also present. The concepts that were thought up were still in place at the end of the tendering process (3).
- Creative meetings are also used to attract 'neighboring' assignments (5).
- Techniques are needed for developing a plan (perspective). Embed the role of the problem owner in the creative meeting. Creative meetings are vital for the survival of BAM (7).
- Creativity techniques can also be used in other meetings, such as work progress meetings (8).

- Innovative ideas are not valued by the client because the client's only aim is to transfer the responsibility for their ideas to the contractor. Better utilize EMVI opportunities (9).
- The CDT training is completely different from the normal courses (10)
- Please hold a network meeting once per year in Bunnik so that new techniques can be practiced (11).
- Lean construction management dovetails with this training. This training is also useful during informal discussions. Can also be used to look for faults and find opportunities with clients. Can be readily used with EMVI (12).

Appendix E

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Handstorm: a fashion design practice[10]

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Abstract
This article reports the experience of the application of the *handstorm* method with fashion design students from SENAI CETIQT in their final projects. The use of this method aimed to prove the importance of three-dimensional experiments as part of the process of creating a clothes collection.
Keywords: Fashion design. *Handstorm*. Creation. Project. Conceptual matrix. Draping.

INTRODUCTION

In a contemporary, dynamic, hybridized and coded scenario, design becomes complex (MORAES, 2010). This becomes apparent when we realize that, in the current context, consumption has a social significance that communicates and also develops human relations. Goods become indicators of consumer decisions and therefore of the current culture (DOUGLAS; ISHERWOOD, 2010). With this in mind, the product designer, in the specific case of fashion, can harness the physical experience of individuals when they wear what was acquired as a product, in other words, when they actually take on the object. The best way of doing this is, during the design process, to employ the means that help the designer to transform ideas and a complex reality into new product possibilities, imbuing them with meaning.

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[10] This article is a translation by Powerling (Language Unlimited) from the original article Monteiro, G.P. & Queiroz, M. (2013). Handstorm: uma prática para o design de moda [Handstorm: a fashion design practice]. *REDIGE, 4*(1), 13 p.

We understand that, when faced with the challenge of a project in such a fluid and changeable environment, full of coding and intricate representations of social relations, design considerations become relevant to the lecturer, who must question the linear methods that deal with the binomial problem/solution. Uncertainties about the effectiveness of a one-sided view, verified through professional experience, which initially confirms the effectiveness of the method, cast doubt as to whether the solutions found to products actually respond to consumers' needs to express themselves.

In the classroom, this professional reality stimulates the building of knowledge, without mysteries or "black boxes" of creation. Schön (2000) writes about a didactic-pedagogical stance, in which the lecturer encourages the student, through dialogue and specific exercises, to reflect on what they are designing. Since we believe in a design method that is as fluid and dynamic as the context it is aimed at, in this article we put forward a practice that has been studied and trialed with two teams in the Final Project 2 on the Bachelor's degree course in Fashion Design at SENAI CETIQT in Rio de Janeiro.

The first aim of the exercise was to demonstrate if the inclusion of a life-size three-dimensional object would help the student's creative process, by making their ideas tangible and thus make them interact with the constructed object. To include the experiment in the discipline, we took as a basis the Conceptual Matrix seen in Araújo e Queiroz (2007, 2008) and used several times since 2007 on the course in question. We structured the method and analyzed the results, based on bibliographical research, as the best method of validating the conclusions and the concept of fluidity in creation throughout the course of the project.

1 THE DESIGN PROCESS AND THE CONCEPTUAL MATRIX

The Final Project at SENAI CETIQT is highly practical and the result is not just the creation of a fashion collection, researched and developed by consulting specialist books and other methodological resources, but also the creation of a practical application. This is done by the student on their own with guidance from a lecturer.

The structure used in the project as an object for practical study is the same as the one in Queiroz e Abreu (2012) in the article "Metadesign: an experiment in surface design". It is divided into two parts:

1. Metaproject – in the model used in the lessons, this is understood to be a "space for reflection and the creation of design research content" (MORAES, 2010, p.32). It is made up of a knowledge system that includes market research, consumer behavior and technology, and provides a direction for product development. The data collected is recorded in the form of a report, illustrated using iconographic collages of the most significant visual elements of the research.

2. Project – after merging the metaproject with an iconographic and textual record, the product development is carried out. In addition to research into materials in the field, a study is conducted on the application of colors and definitions of modeling for future creations and product experimentation, culminating in technical designs and prototypes.

As a link between the two parts of the project structure, we used the aforementioned Conceptual Matrix as a tool to assist the designer in transforming the project design into innovative products. It mixes intangible attributes from the metaproject's iconographic collages with tangible ones, resulting in a product development map that has a range of color, form and raw material stimuli, which will be used in exercises on creativity.

In this article, we highlight the validity of the Conceptual Matrix as a design tool, as it helps organize the students' research and ideas. Initial enthusiasm leads the student to believe that everything that has been researched is important and can be used. However, cuts have to be made throughout the work. Baxter, the director of the Design Research Center, calls this process a "funnel of decision-making", stating that "compared to the previous stages, the risks and uncertainties start to diminish as decisions are taken" (BAXTER, 2000, p.136). The Conceptual Matrix is represented in the form of a table. Ideally, all the cells should be filled in before starting to design the clothes collection. It therefore operates as a guide, indicating which stages have been completed and which are still outstanding.

2 *HANDSTORM*

This tool is described by Van Gassel (2012), who considers it to be part of the process in a collaborative design, in which a multidisciplinary team develops the objectives of a particular project. It includes design, financial and production alternatives. What particularly interested us about the method described, and led us to adapt it to a practical experiment, was the "doing" phase, culminating with a presentation and critique of the design concept. This phase includes sessions with visual stimulations that are interpreted in different ways - a "vision design session". During these sessions, objects or models are improvised using unusual materials. The author mentions that these objects contribute to a creation of new values. *Handstorm* forms part of these sessions. The practice begins with a specific project that aims to construct metaphorical objects for subsequent analysis and criticism, seeking answers to the project's demands (GASSEL, 2012). In the next step, the designers must give meaning to the metaphorical object, transforming imagination into reality.

By analyzing this method, we understand the great potential for exploratory practice with the students completing the Fashion Design course. The final project is sometimes exhausting for the student as it is the ultimate challenge on the course: to create a fashion collection with innovative values, targeted at a specific consumer profile. As mentioned above, students immerse themselves in the design projects and sometimes find it difficult to translate the information into creative stimuli. The Conceptual Matrix encourages these stimuli. However, we felt there was an absence of specific exercises focusing not only on discovering products but also on promoting dialogue with other colleagues and the supervisor.

The *handstorm* process that we have defined begins with the student's choice of product and their doubts about it, for example, a draping, a type of fabric for particular form or the relationship between colors and form, as shown in Figure 1. In this specific case, the students' queries were about a draping, which arose during the execution of the Conceptual Matrix performed in the week prior to the experimental practice. Throughout the exercise, the supervisors stimulated and actively took part in the activity to create a

dialogue as the prototype was being developed on the mannequin. During the exercise, we tried to keep the atmosphere as relaxed as possible, using ambient music in a well-lit and air-conditioned room with free access by other lecturers and students who interacted with the creative process.

Figure 1 - *Handstorm* executed by the student Carolline Barra to trial different drapings and finishes that appeared as form elements in the Conceptual Matrix.
Source: The Authors

Unlike the method proposed by Van Gassel, which stimulates the creation of metaphorical objects on a reduced scale, we suggested creating drapings modeled on a mannequin, so that the student could apply the product's form on a life-size scale. During this process, the student could use various materials to simulate the qualities that arose in the Conceptual Matrix in terms of the raw material and studies on the relationship between form and color.

Throughout *handstorm*, the students were encouraged to work on and adapt their submissions in the search for new solutions, leading to the creation of a prototype, which we called the "original product". Each proposal made was photographed for the record and for future use when developing the product. As well as taking photographs, some students drew sketches in a notebook, extending the record with technical annotations.

During the exercise, two modeling lecturers were invited, without the students being forewarned of this. They gave their opinions on the draping and suggested alternatives. Initially, we preferred not to mention that the lecturers would be present so as not to intimidate the group who were facing the challenge. They took part in the second half of the lesson, which lasted approximately three hours.

Curiously, the method was initially rejected by the majority of the students. Perhaps this happened because the students were used to starting with a sketch (initially) followed by a technical design. The relationship with the fabric is taken care of by the pattern-maker, who interprets the designs that they receive. This proposal aims to increase contact with visual and tactile textures (DONDIS, 2004, p.70), as well as providing an understanding of the problems pattern-makers face when they see the drawings (such as the distance between buttons, the height of a pocket and the opening of a collar). All these questions surfaced during *handstorm*. The result, noted by the students, was a better control of the process and the possibility of cooperating with the pattern-makers. Student Camilla Lopes Ferreira (fig. 2), for example, declared at the end of the lesson that she was keeping the pieces from her experiment to hand over to the pattern-maker along with the proposed drawings.

Figure 2 - *Handstorm* executed by student Camilla Lopes Ferreira who claimed she will take the result to the pattern-maker.
Source: The Authors

Another factor to be highlighted was the students' concerns about carrying out the work using the draping technique, which is different to *handstorm's* proposed experimentation. Student Elisangela Ferreira, whose job is to design party clothes (Figure 3), was one of these. It was only after completing her look carefully using the draping technique that she allowed herself to experiment, such as playing around with the armhole and using other fabrics. This was the most productive part of her work. Particularly when she started testing how to make reversible party clothes (the length of the long gown could be hitched up, turning it into a short smart casual dress).

Figure 3 - *Handstorm* executed by student Elisangela Ferreira, who experimented with reversible dresses.
Source: The Authors

Another case that was reported was the experience of student Jessica Oliveira. She was not concerned about the modeling but rather about the form and volume she wanted to show. When she thought the look was ready, she began to deconstruct it, not only investigating other solutions for the collar and armhole but also the finish, such as the detail of strips of fabric across the back (Figure 4).

Figure 4 - *Handstorm* executed by student Jessica Oliveira, who investigated new armholes and finishes, deconstructing the look after having completed it.
Source: The Authors

Although the experiment was helpful in checking the position of the pocket and the forms, student Thales Alves did not hide his frustration with the result (Figure 5). The fabric chosen for the clothes was sweatshirt material, which rolls up when it is cut, meaning that the finish is poor.

Figure 5 - *Handstorm* executed by student Thales Alves.
Source: The Authors

Student Luana Duarte de Oliveira was one of the most daring ones during *handstorm*. She began timidly and unenthusiastically but, little by little, started to become involved in the exercise, investigating the fabrics' textures and colors as a way of achieving voluminous shapes for her children's piece (Figure 6).

Figure 6 – Student Luana Duarte de Oliveira being assisted by modeling lecturer Alan Kardec during the exercise. Luana investigated colors and textures.
Source: The Authors

After completing the work, the students who took part in the exercise were given a questionnaire, following a model based on the Van Gassel questionnaire.

Table 1: Model questionnaire given to the students.

<table>
<tr><th rowspan="2">Question – Affirmative</th><th colspan="5">Score on a scale from 1 to 5</th></tr>
<tr><th>1
not very</th><th>2
a little</th><th>3
neither a little nor a lot</th><th>4
quite a lot</th><th>5
a lot</th></tr>
<tr><td>Did you like to design in a group?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Did you find it easy to put the clothes together?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Was the process pleasant?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Did working in a classroom rather than on your own give you better results?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Did you learn from your friend’s work?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Did you think that the look you created was significant in representing your collection?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Were you satisfied with the result?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Did you have the energy to maintain concentration during the process?</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="6">What is your MAIN feeling about the HANDSTORM proposal?</td></tr>
<tr><td>BEFORE
( ) Frustration
( ) Anger
( ) Fear
( ) Waste of time
( ) Indifferent
( ) Satisfied
( ) Very satisfied
( )</td><td colspan="3">DURING
( ) Frustration
( ) Anger
( ) Fear
( ) Waste of time
( ) Indifferent
( ) Satisfied
( ) Very satisfied
( )</td><td colspan="2">AFTER
( ) Frustration
( ) Anger
( ) Fear
( ) Waste of time
( ) Indifferent
( ) Satisfied
( ) Very satisfied
( )</td></tr>
</table>

Source: The Authors

Note: Questionnaire conducted based on Gassel’s model questionnaire.

Charts with responses

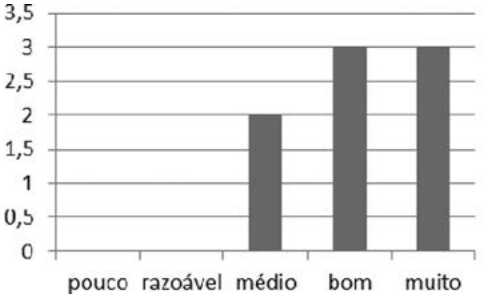

Diagram 1: Do you like to design in a group?

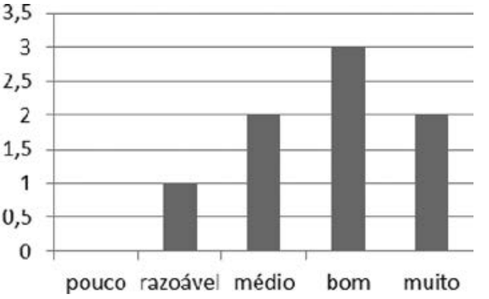

Diagram 2: Did you find it easy to put the clothes together?

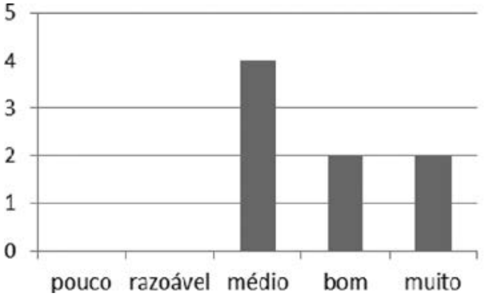

Diagram 3: Was the process pleasant?

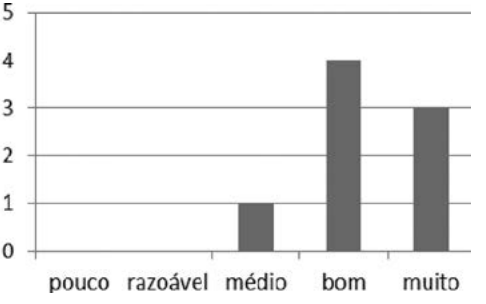

Diagram 4: Did working in a classroom rather than on your own give you better results?

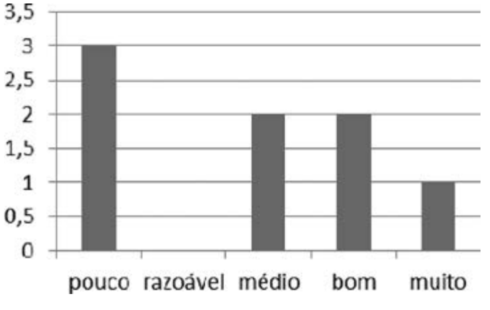

Diagram 5: Did you learn from your friend's work?

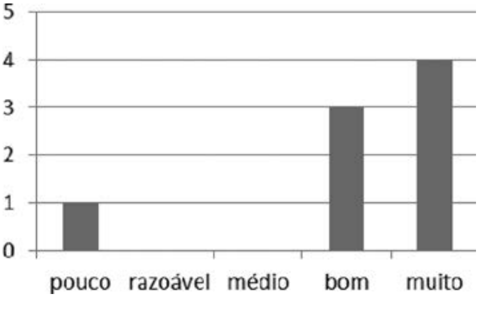

Diagram 6: Did you think that the look you created was significant in representing your collection?

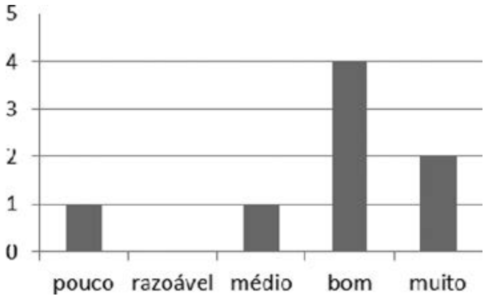

Diagram 7: Were you satisfied with the result?

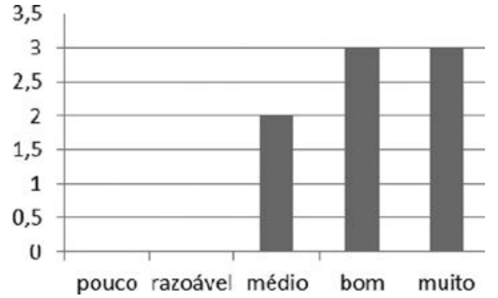

Diagram 8: Did you have the energy to maintain concentration during the process?

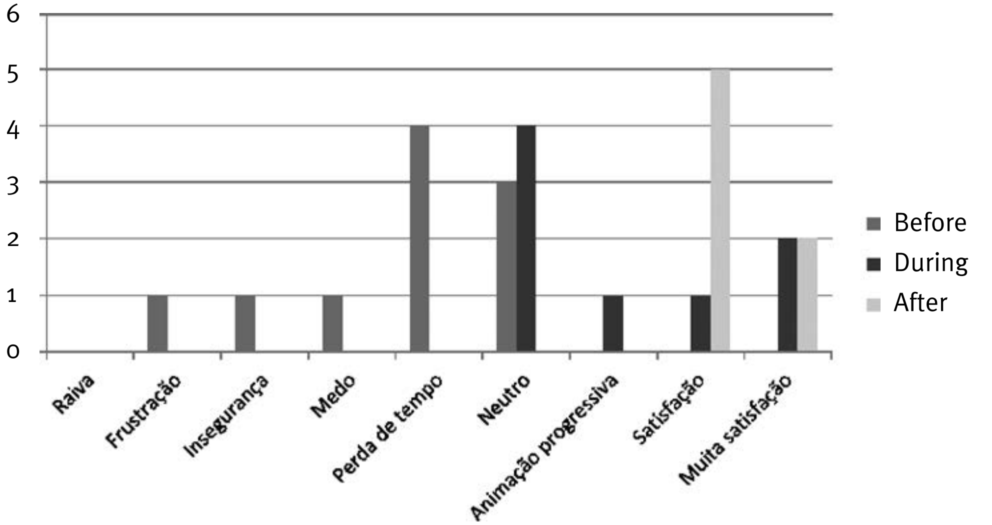

Diagram 9: What is your MAIN feeling about the *HANDSTORM* proposal?
Source: The Authors

Placing the responses in charts allowed us to verify the teachers' views on the exercise and the final result, leading to greater accuracy in this article's conclusions.

CONCLUSIONS

As can be seen in the charts relating to the questionnaire, there was initial resistance from the students, either due to fear or because they felt it would be a waste of time. This resistance diminished when they began the exercise. During the practical exercise, they understood how important it was to have contact with a three-dimensional model. This became clear when problems arose as they were dealing with the tangible reality of the mannequin. They found errors in some definitions that had been thought out on paper. Innovative solutions were also found to the structure of the clothes, in terms of modeling, fabrics and colors. This was evident in the responses, in which they stated that they were satisfied with the *handstorm* results.

The modeling lecturers' presence emphasized design thinking in the structure of the object and gave the students construction elements that had been left out of the designs created on paper, where anything is possible.

As for the supervisors, it became clear that setting up exercises to create life-size models is essential in product development. This fact became crystallized during the construction of the method when seeing how the students reacted. Initially timid when faced with the mannequin, they let go, creatively speaking, when they realized that they would not be judged, but rather stimulated in the creation of innovative solutions to their project dilemmas.

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Summary

This is a summary of the Ph.D. research carried out at Eindhoven University of Technology (TU/e): *Handstorm principles for creative and collaborative working*. The research will be summarized chapter by chapter.

From field problem to research objective (Chapter 1)

Creative and collaborative working between users, developers, designers and builders is necessary to be able to respond to developments, such as increased mechanization and automation of the workforce on the construction site, the enlargement of the number of performance-oriented tenders, the increasing Design, Build, Finance, Maintain and Operate (DBFMO) contracts and a stronger focus on identifying the needs and values of both the client and user. Professionals have an insufficient command of creative and interdisciplinary collaboration skills to be able to respond to these developments.

For this study, the field problem is as follows: *Creative and collaborative working during face-to-face design meetings in the Architectural Engineering and Construction (AEC) sector is not planned, organized or conducted with adequate knowledge or skills.* To resolve this field problem, this research project adopts an approach in which professionals improve their knowledge and skills by attending a course on the facilitation of design meetings. The main aim of the creativity facilitation course is *to teach professionals how to better plan, organize and conduct face-to-face design meetings in the AEC sector*. The sub-aims of this course can be defined as follows:

i. for client satisfaction to be achieved despite the different languages, tools, etiquette, unwritten rules and scientific paradigms applicable among construction professionals;

ii. for the facilitator to share the problem and solution with the participants;

iii. for the participants to learn from each other's different areas of expertise and to work towards a joint design (designing together is learning together);

iv. for the professionals' specific skills and intelligence to be utilized;

v. for an open culture to be pursued by respecting each other, abandoning personal agendas and reflecting on the process completed;

vi. for a specific set of design principles to be utilized.

In practice, similar courses and design principles are available. However, an inventory has shown that the solutions available are limited in their suitability for the achievement of the sub-aims set for the course envisaged.

In developing the creativity facilitation course and the corresponding design principles, knowledge from the following science domains was utilized: *building design management* and *small group creativity*. An inventory of requirements described in the literature from the relevant domains and the experiences of the researcher show that professionals do not have sufficient knowledge and skills to facilitate creative and collaborative working. This

observation results in the following research problem: *Researchers lack insight into the parameters that can be used to describe design meetings and the way in which a facilitation course based on a set of design principles can be used to improve creative and collaborative working during face-to-face design meetings in the AEC sector*.

The research design chosen for this research is *Design Science Research* (DSR). This type of research establishes a connection between practice and scientific knowledge when using concepts like *design principles* and *design solutions*. The course is a design solution that is based on a set of design principles, i.e. normative ideas and statements originating from scientific research. The syntax of a design principle consists of four aspects: the circumstances in which interventions take place (Context), the interventions itself (Interventions), the reason why the interventions work (Mechanisms), and the impact of the interventions (Outcomes). In the relevant literature this classification is referred to as CIMO logic.

Based on the research problem and the research design, the research objective has been formulated as follows: *To improve creative and collaborative working during face-to-face design meetings in the AEC sector by developing a creativity facilitation course based on design principles*.

Research design (Chapter 2)

The research setup 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.

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

1. *Finding parameters to describe collaborative working in design meetings*
2. *Developing the creativity facilitation course based on design principles*
3. *Validating the set of design principles*

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

This design scientific research aimed at 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, with the object of inviting fellow academics to experiment with and report on them. The methodological thoroughness requirement was also met on the basis of this data triangulation – the use of different samples, spaces and persons.

The conditions for successful automated collaboration in construction (Chapter 3)
In this chapter, the first main research topic, *finding parameters to describe collaborative working in design meetings,* was carried out, supported by desk research and a case study. 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 element 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 in a scientific journal: *Automation in Construction* 39 (2014) p. 85-92.

Developing a design principles-based creativity facilitation course (Chapter 4)
In this chapter, 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 Ph.D. 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 was carried out on the basis 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 CIMO logic. These design principles are described briefly below.

- *Plan a detailed meeting plan.*
- *Explain working methods in a simple way.*
- *Put a reluctant participant to work.*
- *Reformulate the question.*
- *Continually change the circumstances.*
- *Let the participants do the work.*
- *Alternate between strict and lenient.*
- *Choose the working method most appropriate for your meeting.*
- *Invite a variety of participants.*
- *Have participants listen to each other.*
- *Create rhythm to activities.*
- *Don't be afraid to deviate from your meeting plan.*
- *Take participants out of their comfort zone.*
- *Let the hands do the thinking.*
- *Close the meeting with perspective.*

The final sub-topic yielded a course program and an enrollment leaflet. This leaflet sums up the sub-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 15 design principles on which the course is based and which have been practiced are also included in the enrollment leaflet.

The chapter ends with a reflection on the design principles and development process. 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.

Validating the set of design principles (Chapter 5)

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

1. *Evaluating the creativity facilitation course in practice;*
2. *Qualifying the implementation of the set of design principles;*
3. *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 'knowledge of joint creative thinking' scored well and that 'improvement of creative behavior' and 'improvement of creative leadership behavior' scored very highly. 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 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 behavior' and 'creative leadership behavior', 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 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 plausible to observe that the use of the design principles developed is useful. The beta test was described in the article by Monteiro, G.P. & Queiroz, M. (2013). *Handstorm: uma prática para o design de moda* [Handstorm: a fashion design practice]. *REDIGE, 4*(1), 13 p.

Conclusions, reflection and discussion (Chapter 6)

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 fulfills 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 creative 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 also yields a set of 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 knowledge 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* the results, the researcher has chosen to implement the course six times in practice, by using existing knowledge, by initiating a beta test, and by evaluating the course on the 'indicative' level.

The *validity* of the set 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 method plausible rival explanations 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 meetings.

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

The research has a number of *limitations* and proposes subjects for *further 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 there is now more data available regarding the impact of the interventions on the outcomes.

Course member experiences 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 what they had learned during the course. This form of self-assessment is less objective than taking measurements before and after training. By further research it might be better to measure the knowledge and behaviors 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 behavior' 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 enhance the coherence.

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

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

Samenvatting

Dit is een samenvatting van de promotiestudie *Handstorm-principes om creatief en interdisciplinair samen te werken,* uitgevoerd aan de Technische Universiteit Eindhoven (TU/e). De studie is per hoofdstuk samengevat.

Van veldprobleem naar onderzoeksdoel (Hoofdstuk 1)
Creatief en interdisciplinair samenwerken tussen gebruikers, ontwikkelaars, ontwerpers en bouwers is nodig om te kunnen voorzien in ontwikkelingen zoals het meer mechaniseren en automatiseren van productietaken op de bouwplaats, het meer aangaan van contracten van het type Design, Build, Finance, Maintain en Operate (DBFMO) en het beter onderkennen van de behoeften en waarden van klanten en gebruikers. De bekwaamheden creatief en interdisciplinair samenwerken zijn bij de professionals in onvoldoende mate aanwezig om op deze ontwikkelingen te kunnen inspelen.

Het veldprobleem luidt: *Creatief en interdisciplinair samenwerken gedurende face-to-face ontwerpbijeenkomsten in de bouwsector worden met onvoldoende kennis en vaardigheden gepland, georganiseerd en geleid*. Om dit veldprobleem op te lossen, is voor het onderzoek een aanpak gekozen die de kennis en vaardigheden van de professionals bijschoolt door hen een cursus faciliteren van ontwerpbijeenkomsten te laten volgen. Het hoofddoel van de cursus creatief faciliteren is *Professionals leren een ontwerpbijeenkomst in de bouwsector beter te plannen, organiseren en leiden*.

De subdoelen van deze cursus zijn als volgt te omschrijven:

i. dat de verschillende talen, gereedschappen, omgangsvormen, ongeschreven regels en wetenschappelijke paradigma's van bouwprofessionals toch leiden tot klanttevredenheid;
ii. dat de facilitator de deelnemers deelgenoot maakt van probleem en oplossing;
iii. dat de deelnemers van elkaars expertise leren en werken aan een gezamenlijk ontwerp (samen ontwerpen is samen leren);
iv. dat er gebruik wordt gemaakt van specifieke vaardigheden en intelligentie van de professionals;
v. dat een open cultuur wordt nagestreefd door elkaar te respecteren, de eigen agenda los te laten en te reflecteren op het doorlopen proces;
vi. dat er gebruik wordt gemaakt van een specifieke set ontwerpprincipes.

In de praktijk zijn vergelijkbare cursussen en ontwerpprincipes beschikbaar. Een inventarisatie hiervan heeft aangetoond aan dat beschikbare oplossingen echter beperkt passen bij de gestelde subdoelen van de gewenste cursus.

Bij het ontwikkelen van de cursus creatief faciliteren en de bijbehorende ontwerp-principes is gebruikgemaakt van kennis uit de wetenschapsdomeinen bouwontwerp-management en creatief-denken-in-groepjes. Een inventarisatie van behoeftes

beschreven in de literatuur in genoemde domeinen en ervaringen van de onderzoeker tonen aan dat er een tekort is aan kennis en vaardigheden bij professionals om creatief en interdisciplinair samenwerken te faciliteren. Deze constatering leidt tot het volgende onderzoeksprobleem: *Wetenschappers hebben gebrek aan inzicht in de parameters waarmee ontwerpbijeenkomsten kunnen worden beschreven en hoe een cursus faciliteren, gebaseerd op een set ontwerpprincipes, creatief en interdisciplinair samenwerken gedurende face-to-face ontwerpbijeenkomsten in de bouwsector verbeterd kan worden*.

Voor de aanpak van het onderzoek is gekozen voor de opzet van *ontwerpgericht wetenschappelijk onderzoek*. Dit type onderzoek verbindt de praktijk met wetenschappelijke kennis bij gebruik van concepten als *ontwerpprincipes* en *ontwerpoplossingen*. De cursus is een ontwerpoplossing die gebaseerd is op een set ontwerpprincipes, namelijk normatieve ideeën en stellingen afkomstig uit de wetenschap. De syntaxis van een ontwerpprincipe bestaat uit vier aspecten: de omstandigheden waarin ingrepen plaatsvinden (Context), de ingrepen zelf (Interventies), de reden waarom de ingreep werkt (Mechanismes) en het effect van de ingreep (Opbrengsten). Deze ordening wordt in de literatuur de CIMO-logica genoemd.

Op basis van het onderzoeksprobleem en de onderzoeksopzet is het onderzoeksdoel als volgt geformuleerd: *Het verbeteren van creatief en interdisciplinair samenwerken gedurende face-to-face ontwerpbijeenkomsten in de bouwsector door het ontwikkelen van een cursus creatief faciliteren die gebaseerd is op een set ontwerpprincipes*.

Ontwerp onderzoek (Hoofdstuk 2)

De opzet van het onderzoek is ontwerpgericht wetenschappelijk. Bij het formuleren van de onderzoeksactiviteiten is gebruikgemaakt van de cyclus *onderzoek-ontwerp-ontwikkeling*. Dit is een model dat kennisstromen en ervaringsstromen tussen praktijk en wetenschap beschrijft.

De centrale onderzoekstaak *Ontwikkel een cursus creatief faciliteren gebaseerd op gevalideerde ontwerpprincipes* is uitgesplitst in drie hoofdonderzoekstaken:

1. *Ontdek parameters die interdisciplinair samenwerken tijdens ontwerpbijeenkomsten beschrijven;*
2. *Ontwikkel een cursus creatief faciliteren die gebaseerd is op een set ontwerpprincipes;*
3. *Valideer de set ontwerpprincipes.*

Bij het uitvoeren van deze taken zijn de onderzoeksstrategieën bureauonderzoek, casestudie, experiment en survey-onderzoek gebruikt.

Bij dit ontwerpgericht wetenschappelijk onderzoek is gestreefd naar maximale praktische relevantie en maximale methodische grondigheid. Aan deze laatste eis is tegemoetgekomen door de ontwikkelde ontwerpprincipes op basis van bestaande wetenschappelijk kennis te ontwikkelen en te valideren door deze in de praktijk te implementeren en te evalueren. Daarnaast is aan maximale methodische grondigheid tegemoetgekomen door bij het toepassen van de methode *plausibel rivaliserende verklaringen* de resultaten op validiteit te onderzoeken. Aan de praktische relevantie is tegemoetgekomen door de cursus gebaseerd op een set ontwerpprincipes in de praktijk te geven. Een bètatest is uitgevoerd door een aantal ontwerpprincipes en evaluatievragen vroegtijdig te publiceren om collega-wetenschappers uit te nodigen ermee te experimenteren en erover te rapporteren. Door deze datatriangulatie – het gebruik van verschillende testen, situaties en personen – is aan de methodische grondigheid verder tegemoetgekomen.

De voorwaarden om succesvol interdisciplinair samen te werken in de bouwsector. (Hoofdstuk 3)
In dit hoofdstuk is de eerste hoofdonderzoekstaak, namelijk *Ontdek parameters die interdisciplinair samenwerken tijdens ontwerpbijeenkomsten beschrijven,* met behulp van bureauonderzoek en een casestudie uitgevoerd. Het bureauonderzoek heeft een onderzoeksoptiek opgeleverd waarmee naar interdisciplinair samenwerken, kan worden gekeken. De casestudie bestond uit het analyseren van 37 bijeenkomsten gedurende de ontwerp- en productiefase van een prototype van een industrieel, flexibel en demonteerbaar bouwsysteem. De gevonden parameters ‘doel bijeenkomst’, ‘leiden van de bijeenkomst’, ‘deelnemers’, ‘werkmethoden’ en ‘resultaat’ zijn verbonden met het basiselement van de Structured Analysis and Design Technique (SADT). Zo is een systeemmodel ontstaan waarmee bijeenkomsten kunnen worden beschreven en ontworpen. De uitvoering van deze hoofdonderzoekstaak is gepubliceerd in het wetenschappelijke tijdschrift *Automation in Construction* 39 (2014) 85-92.

Ontwikkel een cursus creatief faciliteren die gebaseerd is op een set ontwerpprincipes (Hoofdstuk 4)
In dit hoofdstuk is de tweede hoofdonderzoekstaak, namelijk *Ontwikkel een cursus creatief faciliteren die gebaseerd is op een set ontwerpprincipes,* opgesplitst in vier subtaken:

1. *Ontdek mechanismes in PhD-onderzoeken;*
2. *Ontdek succesvolle uitgevoerde ingrepen, ervaren bij experimenten in de bouwsector;*
3. *Ontwikkel ontwerpprincipes door het synthetiseren van de mechanismes en succesvolle ingrepen*;
4. *Ontwikkel een cursus die is gebaseerd op de ontwikkelde ontwerpprincipes.*

Het onderzoek is uitgevoerd aan de hand van bureauonderzoek en experimenten. De subtaken 1, 2 en 3 leverden vijftien ontwerpprincipes op, waarbij de syntaxis van een ontwerpprincipe is geordend volgens de CIMO-logica. Hieronder zijn deze ontwerpprincipes beknopt beschreven.

- *Maak een nauwkeurig draaiboek.*
- *Leg werkmethoden simpel uit.*
- *Zet een onwillige aan het werk.*
- *Herformuleer de vraag.*
- *Wissel voortdurend van omstandigheden.*
- *Leg het werk bij de deelnemers.*
- *Wees afwisselend streng en soepel.*
- *Kies de geschiktste werkvorm voor de bijeenkomst.*
- *Nodig verscheidene deelnemers uit.*
- *Laat deelnemers naar elkaar luisteren.*
- *Geef ritme aan activiteiten.*
- *Blijf niet hangen in het draaiboek.*
- *Haal deelnemers uit hun patronen.*
- *Laat de handen denken.*
- *Sluit de bijeenkomst af met een perspectief.*

De laatste subtaak heeft een cursusprogramma en een wervingsfolder opgeleverd. De folder somt kort de subdoelen van de cursus op: gericht op de bouwsector, betrokken faciliteren, stimuleren van elkaars leren, benutten van elkaars vaardigheden en intelligentie en zorgen voor een open cultuur. De vijftien ontwerpprincipes waarop de cursus is gebaseerd en waarmee geoefend wordt, zijn ook in de wervingsfolder vermeld.

Het hoofdstuk sluit af met een reflectie op de ontwerpprincipes en het ontwikkelingsproces. De ontwerpprincipes dekken de bijeenkomstparameters 'leiden van de bijeenkomst', 'deelnemers' en 'werkmethoden' gelijkmatig per ontwerpprincipe af; er is per ontwerpprincipe achtergrondinformatie gegeven en er is aangetoond dat ontwerpprincipes de subdoelen van de cursus versterken. De uitvoering van de hoofdontwikkelingstaak heeft een methode opgeleverd die wetenschappelijke kennis en praktijkresultaten synthetiseert tot nieuwe ontwerpprincipes.

Valideer de set ontwerpprincipes (Hoofdstuk 5)
De derde hoofdonderzoekstaak, *Valideer de set ontwerpprincipes,* is opgesplitst in drie subtaken, namelijk:

1. *Evalueer de cursus creatief faciliteren die is gebaseerd op de set ontwerpprincipes;*
2. *Kwalificeer de werking van de set ontwerpprincipes;*
3. *Beoordeel de validiteit van de evaluatie en kwalificatie resultaten.*

De cursus is na zesmaal uitvoeren geëvalueerd waarbij de leerresultaten en tevredenheid van de deelnemers door middel van een ondervraging zijn gemeten. Deze meting heeft aangetoond dat 'kennis van samen creatief denken' goed scoorde en dat 'verbetering creatief gedrag' en 'verbetering creatief leiderschapsgedrag' zeer goed scoorden. Verder waren de cursusdeelnemers zeer tevreden en oefenden ze na de cursus in de praktijk de geleerde vaardigheden. De bruikbaarheid van de set ontwerpprincipes is gekwalificeerd door de samenhang te meten tussen enerzijds de beschrijvingen van de onderzoeksvragen in relatie met de afhankelijke variabelen 'kennis van samen creatief denken', 'creatief gedrag' en 'creatief leiderschapsgedrag', en anderzijds de volledige beschrijvingen van de ontwerpprincipes. Een samenhang kan worden beoordeeld als *redelijk* op de 5-punts Likert schaal (i.c. zwak, redelijk, gemiddeld, goed en de beste).

De bètatest is uitgevoerd aan de Federal University of Juiz de Fora in Brazilië tijdens een bachelorcursus gebaseerd op het gebruik van ontwerpprincipes. Uit de antwoorden van de evaluatievragen is gebleken dat de studenten tevreden waren met de cursus (schaal een tot vijf en een gemiddelde van 3,75 (standaarddeviatie 1,28 en N=8)). Bij aanvang was er weerstand bij de studenten, maar gedurende de uitvoering van de test verdween deze. De begeleiders vonden dat bij toepassing van de ontwerpprincipes de resultaten beter waren in vergelijking met situaties waarbij deze ontwerpprincipes niet werden gebruikt. Het lijkt aannemelijk te constateren dat het gebruik van de ontwikkelde ontwerpprincipes nuttig is. De bètatest is beschreven in de wetenschappelijke publicatie van Monteiro, G.P. & Queiroz, M. (2013). Handstorm: uma prática para o design de moda [Handstorm: a fashion design practice]. *REDIGE, 4*(1), 13 p.

Conclusies, reflectie en discussie (Hoofdstuk 6)

De centrale onderzoekstaak, *Ontwikkel een cursus creatief faciliteren gebaseerd op gevalideerde ontwerpprincipes,* resulteert in een aantrekkelijke en breed toepasbare oplossing voor het vastgestelde veldprobleem. Het komt ook tegemoet aan de behoeften 'structureren van face-to-face bijeenkomsten' en 'creativiteitsverhogende richtlijnen voor geschoolde facilitators'. Het vervullen van deze behoeften levert nieuwe kennis op voor de wetenschapsdomeinen bouwontwerpmanagement en creatief-denken-in-groepjes.

De cursus creatief faciliteren is *toepasbaar* voor professionals die werken bij ondernemingen die betrokken zijn bij prestatiegerichte aanbestedingen in de bouwsector. De cursus is ondertussen onderdeel van het onderwijsprogramma van de BAM Business School. Het onderzoek levert ook een set CIMO-gestructureerde ontwerpprincipes op die te gebruiken zijn als een handleiding voor het plannen, organiseren en leiden van allerlei soorten ontwerpbijeenkomsten. Verder kunnen de ontwerpprincipes ook worden gebruikt voor het ontwerpen van creativiteitstechnieken, zoals twee simulatiespelen ('Partner selection' en 'Creative supply and demand') en twee creativiteitstechnieken ('Constructing a platform' en 'Constructing metaphoric objects'). Onder de merknaam Handstorm® wordt het praktische gebruik van de ontwerpprincipes op de website www.handstorm.nl uitgedragen.

Ook leverde het onderzoek (i) een systeemmodel om bijeenkomsten te bedenken en te beschrijven, (ii) een procedure om ontwerpprincipes te ontwikkelen door het synthetiseren van de mechanismes en succesvolle ingrepen, (iii) een vragenlijst om de cursus bij deelnemers te evalueren, (iv) een toepassing van het doorlopen van de cyclus onderzoek-ontwerp-ontwikkeling, en tenslotte (v) een procedure om gevonden meetresultaten met behulp van de methode plausibel rivaliserende verklaringen op validiteit te onderzoeken. Deze resultaten komen ten goede als nieuwe kennis aan het domein ontwerpgericht wetenschappelijk onderzoek.

Om de *betrouwbaarheid* van de resultaten te verhogen heeft de onderzoeker zes cursussen geëvalueerd, is bij de ontwikkeling van de ontwerpprincipes gebruik gemaakt van bestaande kennis, is een bètatest geïnitieerd en is de cursus geëvalueerd op het niveau *indicatief*.

De *validiteit* van de set ontwerpprincipes is beoordeeld door het kwalificeren van de evaluatieresultaten en de resultaten van de bètatest. Bij het onderzoeken van de validiteit van de set ontwerpprincipes is gebruikt gemaakt van de methode plausibel rivaliserende verklaringen. Een bètatest die uitgevoerd is aan een universiteit in Brazilië toont aan dat de ontwerpprincipes geschikt zijn voor het plannen en organiseren van onderwijsbijeenkomsten.

Door de ontwerpprincipes robuust te beschrijven, wordt bijgedragen aan een *brede inzetbaarheid* bij uiteenlopende vormen van creatief en interdisciplinair samenwerken.

Het onderzoek heeft *beperkingen* en geeft suggesties voor *verder onderzoek*. De cursus is geëvalueerd op het niveau *indicatief* omdat deze voor de eerste maal werd uitgevoerd. Bij toekomstig onderzoek zou de cursus op het niveau *causaal* kunnen worden geëvalueerd, omdat er dan meer kennis beschikbaar is over het effect van de ingrepen. De ervaringen van de cursusdeelnemers werden gemeten met een vragenlijst en werden gemeten na zes cursussen. Aan de cursusdeelnemers werd gevraagd te beoordelen in welke mate ze een bepaalde vaardigheid hebben geleerd. Deze vorm van zelfbeoordeling is niet echt objectief. De meting heeft wel per aspect van gedrag plaatsgevonden en er is gebruikgemaakt van bewezen meetstaten. Bij toekomstig onderzoek zou een vóór- en nameting objectiever kunnen zijn. De bruikbaarheid van de set ontwerpprincipes is aangetoond door de samenhang te meten tussen de tekst van de vragen en de sleutelwoorden van de ontwerpprincipes. Deze samenhang wordt beschouwd als *redelijk*, maar er zijn wel verschillen tussen de leerresultaten 'creatief gedrag' en 'creatief leiderschapsgedrag' in relatie tot de ontwerpprincipes te constateren. Bij verder onderzoek zou de kennis van de deelnemers over de ontwerpprincipes nauwkeuriger gemeten moeten worden, wat de samenhang dan zou kunnen verhogen. Het SADT-systeemmodel voor bijeenkomsten is ontleend aan slechts één case, maar is talrijke keren gebruikt voor het analyseren en beschrijven van uiteenlopende bouwprocessen tijdens de Masteropleiding Construction Management en Engineering aan de Technische Universiteit Eindhoven.

Ook het testen van de werking van de Handstorm®-principes tijdens alle fasen van creatieve en interdisciplinaire samenwerkingsprocessen in bijvoorbeeld de ICT-sector, overheid en zorg is een zinvol onderzoek. Het is wenselijk ook te weten of de principes ook buiten de context van Nederland en Brazilië zijn te gebruiken.

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Curriculum vitae

Frans J.M. van Gassel obtained his MSc in Mechanical Engineering (Design of Production Systems) at the Eindhoven University of Technology in 1976. Subsequently he stepped into the industry as production manager for steel constructions (1977-1979), and later as head of product development for modular systems in construction (1979-1990). He then returned to his Alma Mater as an assistant professor, lecturing in subjects such as mechanization on the construction site, collaborative design, creativity and innovation in design teams, robotics and home automation, and industrialized construction. His research interests focus on the design team and the design environment in relation to design performance.

He received the 2010 Tucker-Hasegawa award of the IAARC (International Association of Automation and Robotics in Construction), was runner-up in the 2006 Teaching Method competition for elementary schools in the Netherlands, became a Member of the Royal Order of Orange-Nassau in 2002 for his societal activities as founder and board member of a youth center, chairperson of the community council for welfare works, and founder, manager and board member of a local recycling center. Previously (1992) the Beesel Community Council awarded him their Environmental award, while in 1989 he got the ION award in industrial design for the Max-60 construction system. In 2003 he served as conference secretary for the ISARC, the International Symposium on Automation and Robotics in Constructions, and in 2012 as conference secretary and treasurer of ISG*ISARC 2012. ISG is the abbreviation for the International Society of Gerontechnology.

In 2013, he organized a symposium, which features ten parallel creative workshops at a marketplace with a joint introduction and a conclusion. This public innovation market was held because of his retirement. On the occasion of the 60th anniversary of the Slovak University of Technology, the department Building Technology awarded him (with Mr Ger Maas) a commemorative medal for their active cooperation with the department and their long and meritorious work in pedagogical and research activities. Since 2004 till now he is delegated manager of the Universitair Centrum voor Bouwproductie (UCB).

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The following publications of the author have been downloaded from PURE, the research information system of the Eindhoven University of Technology (TU/e).

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Ingrid Janssen

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Roel Gijsbers

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Yanliu Lin

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Pauline van den Berg

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Martijn Vercammen

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Lisje Schellen

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Gaby Abdalla

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Mônica do Amaral Melhado

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Brano Glumac

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Şehnaz Cenani Durmazoğlu

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Functionality and Adaptability of Design Solutions for Public Apartment Buildings in Ghana
Stephen Agyefi-Mensah

nr 188
A Construction Waste Generation Model for Developing Countries
Lilliana Abarca-Guerrero

nr 189
Synchronizing Networks: The Modeling of Supernetworks for Activity-Travel Behavior
Feixiong Liao

nr 190
Time and Money Allocation Decisions in Out-of-Home Leisure Activity Choices
Gamze Zeynep Dane

nr 191
How to Measure Added Value of CRE and Building Design
Rianne Appel-Meulenbroek

nr 192
Secondary Materials in Cement-Based Products: Treatment, Modeling and Environmental Interaction
Miruna Florea

nr 193
Concepts for the Robustness Improvement of Self-Compacting Concrete: Effects of Admixtures and Mixture Components on the Rheology and Early Hydration at Varying Temperatures
Wolfram Schmidt

nr 194
Modelling and Simulation of Virtual Natural Lighting Solutions in Buildings
Rizki A. Mangkuto

nr 195
Nano-Silica Production at Low Temperatures from the Dissolution of Olivine - Synthesis, Tailoring and Modelling
Alberto Lazaro Garcia

nr 196
Building Energy Simulation Based Assessment of Industrial Halls for Design Support
Bruno Lee

nr 197
Computational Performance Prediction of the Potential of Hybrid Adaptable Thermal Storage Concepts for Lightweight Low-Energy Houses
Pieter-Jan Hoes

nr 198
Application of Nano-Silica in Concrete
George Quercia Bianchi

nr 199
Dynamics of Social Networks and Activity Travel Behaviour
Fariya Sharmeen

nr 200
Building Structural Design Generation and Optimisation including Spatial Modification
Juan Manuel Davila Delgado

nr 201
Hydration and Thermal Decomposition of Cement/Calcium-Sulphate Based Materials
Ariën de Korte

nr 202
Republiek van Beelden: De Politieke Werkingen van het Ontwerp in Regionale Planvorming
Bart de Zwart

nr 203
Effects of Energy Price Increases on Individual Activity-Travel Repertoires and Energy Consumption
Dujuan Yang

nr 204
Geometry and Ventilation: Evaluation of the Leeward Sawtooth Roof Potential in the Natural Ventilation of Buildings
Jorge Isaac Perén Montero

nr 205
Computational Modelling of Evaporative Cooling as a Climate Change Adaptation Measure at the Spatial Scale of Buildings and Streets
Hamid Montazeri

nr 206
Local Buckling of Aluminium Beams in Fire Conditions
Ronald van der Meulen

nr 207
Historic Urban Landscapes: Framing the Integration of Urban and Heritage Planning in Multilevel Governance
Loes Veldpaus

nr 208
Sustainable Transformation of the Cities: Urban Design Pragmatics to Achieve a Sustainable City
Ernesto Antonio Zumelzu Scheel

nr 209
Development of Sustainable Protective Ultra-High Performance Fibre Reinforced Concrete (UHPFRC): Design, Assessment and Modeling
Rui Yu

nr 210
Uncertainty in Modeling Activity-Travel Demand in Complex Uban Systems
Soora Rasouli

nr 211
Simulation-based Performance Assessment of Climate Adaptive Greenhouse Shells
Chul-sung Lee

nr 212
Green Cities: Modelling the Spatial Transformation of the Urban Environment using Renewable Energy Technologies
Saleh Mohammadi

nr 213
A Bounded Rationality Model of Short and Long-Term Dynamics of Activity-Travel Behavior
Ifigeneia Psarra

nr 214
Effects of Pricing Strategies on Dynamic Repertoires of Activity-Travel Behaviour
Elaheh Khademi

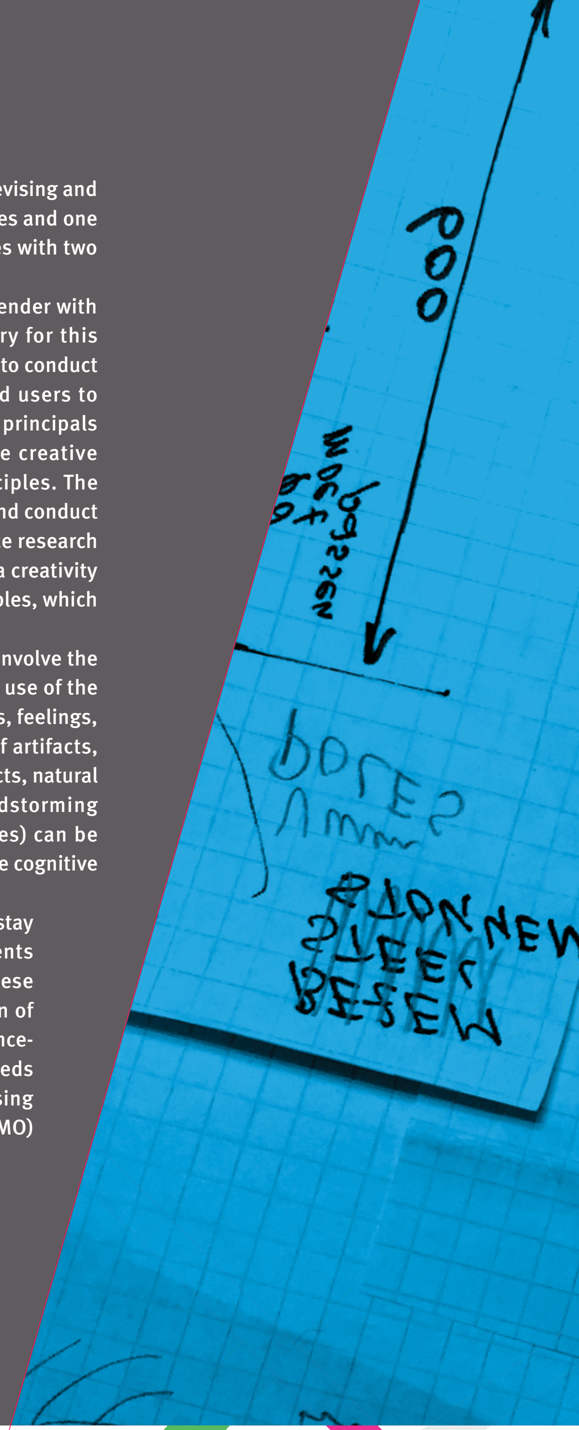
Handstorm principles

A Dutch consortium received an order to build a sea lock by devising and bidding a smart design. They designed two identical lock gates and one back up copy, which is much cheaper than two different gates with two matching back-up copies.

How can a design manager organize the development of a tender with a similarly smart design? Creative leadership is necessary for this development. Creative leadership skills enable professionals to conduct creative collaboration between designers, specialists and users to devise ideas and new designs to solve the problems of the principals and society. To support the design manager during these creative processes, the author has developed a set of design principles. The Handstorm principles help design managers plan, organize and conduct face-to-face design meetings. According to the design science research approach, the Handstorm principles have been validated by a creativity facilitation course that was developed based on these principles, which was successfully implemented six times in practice.

As the name Handstorm suggests, these principles not only involve the use of both the left and right sides of the brain, but also the use of the rest of the body, employing one's hands, taste buds, gestures, feelings, voice, and more. Designs are typically made with the help of artifacts, images, photos, language, analogies, stories, boundary objects, natural materials, writing implements, paper, and so forth. Handstorming (working with materials, tools, constructions and machines) can be considered as an enrichment of brainstorming, which is a more cognitive and intellectual process.

This book presents design principles that help professionals stay flexible and resilient when dealing with recent developments in the architecture, engineering and construction sector. These developments are increased mechanization and automation of the workforce on the construction site, increasingly performance-oriented tenders with a stronger focus on identifying the needs and values of both the client and the user, and the increasing number of design, build, finance, maintain and operate (DBFMO) contracts.



Handstorm.

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