CO-DESIGNING INTERACTIVE SPACES FOR AND WITH DESIGNERS: SUPPORTING MOOD-BOARD MAKING

ANDRES LUCERO VERA

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This thesis explores why and how designers use mood boards in the early stages of the design process, and how augmented reality can support mood boarding by following a user-centered design approach. The main research questions in this thesis are: 1) what are mood boards and why do designers use them, and 2) how can augmented reality tools provide support for professional users in their work. Mood boarding is explored in depth by means of interviews with Dutch and Finnish practicing designers. The knowledge gained in these interviews is fed into co-design sessions with Dutch and Finnish designers in which researchers and end-users (i.e. designers) create augmented reality tools that support mood boarding. The co-designed tools are later evaluated to address the two research questions. In terms of the complete research process, this work also leads to an improved understanding of using different user-centered design methods (i.e. cultural probes, workshops, contextual inquiries, interviews, co-design sessions, prototyping) when trying to unveil the needs of users.

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PROEFONTWERP

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To Sole, to Rayen, to Antü

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Contents

INTRODUCTION

1   Introduction

1.1   Designers and their mood boards

As a trained graphic designer and as a teacher in a design school in Chile, I had never come across mood boards (MBs) before. I had made collages and used images as part of a design process, however, there seemed to be something about MBs that was different from the collages I used to make.

I first heard about MBs in Philips Research Eindhoven. An industrial design student from TU Delft who was working on her graduation project presented some MBs she had made for herself, *"for my own inspiration"*. As she was presenting her work, people around the table were divided among those who seemed to understand and respect what she had done and why she had done it, and the other half did not seem to get it. Among the latter, one person asked her with a sarcastic tone: *"So, you picked these images yourself, you decided where the images would go (layout), and finally you glued them to this board. And you made all this to find inspiration for yourself?"* This comment shows that people know very little about what MBs are and why designers use them. I was among those who did not get it.

When I later joined Industrial Design at the Eindhoven University of Technology (TU/e) and came into contact with other designers from Philips and TU Delft, I became more aware of MBs. For some reason, whenever I spoke to designers, MBs seemed to naturally pop into the discussion. On a visit to ID-StudioLab in Delft, a professor there started talking about MBs. "MBs seem to be very important to designers, but we have no overview or theory of how precisely they are made and used, and how they should be supported." There was something about MBs that I was not aware of and I wanted to know exactly what.

Later on, at a Human-Computer Interaction (HCI) conference, we were discussing our experiences working in multi-disciplinary teams with a Finnish researcher from the Helsinki University of Technology, when he made this observation: *"...you know designers and how they like their MBs!"* Around that time I decided to look closer into MBs.

These three examples show that 1) designers use MBs for their work, 2) designers are very fond of them, and 3) that there is very little understanding of why designers use MBs.

1.2   User-driven innovation

The field of HCI has been investigating how people interact with computer systems at work (and more recently at home), trying to help them achieve their goals. Within HCI, researchers have already identified the potential behind interactive vertical and horizontal surfaces as a more natural and familiar setting to design (collaborative) interactions. Some notable examples of interactive tables include the

DigitalDesk [Wellner 1993], DiamondTouch [Dietz & Leigh 2001], Sensetable [Patten *et al.* 2001], Lumisight [Matsushita *et al.* 2004], and more recently Microsoft's Surface [Surface 2007]. Prominent examples of interactive wall displays include Tivoli [Pedersen *et al.* 1993], Flatland [Mynatt *et al.* 1997], Hello.Wall [Prante *et al.* 2003], and the prototype developed by Vogel to study interactive public ambient displays [Vogel & Balakrishnan 2004]. Although initially research in this area was mostly driven by technology, we have slowly started to witness a user-perspective approach, studying the needs and aspirations of users.

Within our User Centered Engineering (UCE) group, we had built augmented reality (AR) systems, which allowed us to gain experience on aspects such as technology and usability. Previous designs were mostly based on relevant literature of work practices and less so on active user exploration. Our group had been following the traditional technology push approach that is commonly taken by computer science departments when working on HCI. For sure, the technology push approach is one good way of doing research and fostering innovation. However, it is not the only one.

Before starting my PhD I spent one year in Philips Research Eindhoven, working on a project that involved the design and evaluation of an interaction solution for an advanced ambient lighting system for the bathroom in HomeLab. In the project at Philips, I followed a user-centered design (UCD) approach that led to user-driven innovation. In this thesis, I take a similar approach that consists of letting potential users guide the innovation process. Basically, it implies conducting a series of user studies (i.e. cultural probes, workshops, contextual inquiries, interviews, video observations) to first explore the work (i.e. design practice) of professional users, then identify a relevant task for these professional users (i.e. industrial designers), and finally try to understand the essence of this task before making any attempt of providing support for it with new technologies. Finally, the results of these studies are fed into co-design sessions in which end-users actively create sensible solutions and tools that support their work and in their real context. In this thesis UCD is used as a research methodology [Spinuzzi 2005].

1.3 Goal and relevance

People have different ways of communicating with each other and building an understanding in the context of professional work (e.g. face-to-face meetings, phone calls, email, videoconference, etc.). Designers use mood boards as means to communicate and reach agreements with their clients (or within a design team) in the beginning of the design process. Mood boarding helps explore the available design space or range of possibilities that emerge from the design brief. It does so by visualizing rough and undefined ideas using mostly visual materials (i.e. images from books or magazines). A MB defines and communicates the direction for a design project. But what is our understanding of design practice in relation to MBs?

This work creates a deeper understanding of design practice or how designers work in general, and specifically on why and how designers use MBs for their work. As practitioners, researchers and teachers in design we believe there are still aspects behind MBs that need to be discovered.

HCI researchers have already identified the potential behind interactive vertical and horizontal surfaces as a more natural and familiar setting to design (collaborative) interactions. Traditionally, research in the area of AR has been mostly driven by technology. As a result, one fundamental facet has been missing: the user. In this thesis we follow an alternative UCD approach that leads to user-driven innovation.

This thesis explores why and how designers use MBs in the early stages of the design process, and how AR can support mood boarding by following a UCD approach. The main research questions in this thesis are: 1) *what are MBs and why do designers use them*, and 2) *how can AR tools provide support for professional users in their work*. We address these two questions by co-designing and evaluating AR tools that support mood boarding for designers.

In terms of the complete research process, this work also leads to an improved understanding of using different UCD methods (i.e. cultural probes, workshops, contextual inquiries, interviews, co-design sessions) when trying to unveil the needs of users.

1.4 Design paradigms

Our understanding on the notion and practice of design has historically been linked to the disciplines of graphic and industrial design. In this traditional conception of design, the designer is mostly interested in the relationship between people and the resulting products, be it a poster, a sign, or a piece of furniture. Two design paradigms naturally belong to this old notion of design: *design as rational problem solving* and *design as reflective practice*.

A first paradigm of design methodology, *design as rational problem solving*, consists of a basic design cycle of four main sequential phases that designers go through in search for the best possible solution: analysis, synthesis, simulation, and evaluation. The designer first clearly defines the problem space and then analyzes it to formulate requirements. Next, designers must diverge and generate many possible solutions, exploring the potential consequences behind each, ultimately converging to select the most manageable ones. Finally, the chosen solution is implemented. This sequence can be repeated making this design process iterative. Dorst [2007] argues that *design as rational problem solving* can be applied when the design problem is clearly formulated and thus design goals are explicit, clear and stable. However, due to the ill-defined and unstructured nature of most design problems we encounter in real life, in most cases this design approach does not work [Schön 1983]. It is simply not possible to have all the necessary information to solve a design problem [Cross

2006]. Designers would have to make an *a priori* judgment of the complexity of the design challenge and its solution domain [Hummels & Frens 2008].

A second paradigm of design methodology, *design as reflective practice* [Schön 1983], also consists of four sequential phases: naming, framing, moving, and evaluating. The first two phases, naming and framing, can be mapped to the analysis phase of *design as rational problem solving*. Naming consists of identifying all the relevant factors in the situation, which later helps frame the design problem. The designer can then move towards a solution, consider the situation again, and create new moves. Finally, the moves or solutions are evaluated. In this process, Schön stresses the importance of linking the design process to a concrete design situation, integrating knowledge, skills, and attitude.

As technology became part of people's everyday lives, designers took on a more holistic approach in trying to understand how people interact with technology, and thus new design disciplines emerged (i.e. interaction, experience, and sustainable design). New paradigms of design methodology have also naturally come into existence to reflect some of these changes in design. Kees Dorst [2007] has explored other paradigms of design methodology: *design as applied creativity*, *design as learning*, and *design as evolution*.

In *design as applied creativity*, designers focus their creative skills and analytical reasoning towards a solution and not on the problem. This approach seems especially relevant for chaotic problems that do not lend themselves to analysis. In *design as learning*, designers take a different approach by gradually gathering knowledge on both the design problem and the possible routes towards solutions. Designers go through rounds of proposing, experimenting, and thus learning their way towards a solution. *Design as evolution* consists of a gradual process of tuning primitive (vague) ideas towards evolved (knowledgeable) possible solutions over generations. This evolution refers both to the problem definition and the ideas for solution, the final aim being the generation of a matching problem-solution pair.

A final paradigm of design methodology, *design as reflective transformation* [Hummels & Frens 2008], is a design process based on four principles: 1) flexibility and individuality, 2) integrating knowledge, skills and attitudes, 3) supporting transformation, and 4) creating moments of reflection. *Design as reflective transformation* is a holistic, open, and flexible design process that allows designers and design students find their preferred way of designing future interactive intelligent products and services. The designer can be involved in any of five activities (i.e. envisioning, sensing, analyzing, ideating and validating), changing as many times as necessary, and in no particular order. The path that designers choose to follow will be on one hand influenced by the nature, context and complexity of the design problem, and on the other by their individual designerly skills.

The design paradigms mentioned earlier describe different approaches taken

by designers when confronted with new design challenges. Some design problems naturally lend themselves to more rigid paradigms such as *design as rational problem solving* while others benefit from flexible paradigms like *design as reflective transformation*. The same observation holds for the designers themselves who feel more comfortable with one paradigm over another based on their interests and skills. However, regardless of the paradigm, all design problems share at the core a degree of uncertainty, conflict, choice, and compromise that designers must deal with and that are part of the *"delight of being a designer."* [Cross 2006]

The different design paradigms have evolved together with emerging design disciplines in an attempt to understand the domestication of technology or how new technology is appropriated by its users. Starting from a specific design activity such as the creation of MBs, in this thesis I begin to build a holistic view on how interactive design spaces can provide a better support for designers in their individual design processes. Similarly to the creation of MBs, the design process I am supporting is by nature explorative, open, and flexible and thus bares close ties with the *design as reflective transformation paradigm*. This paradigm reflects the natural evolution of the design field and better responds to the dynamic, multidisciplinary, and multicultural work needed to create future interactive intelligent products and services.

1.5 Research approach

In this thesis a *research through design* approach is followed, in which the design process is used as a form of research to contribute to a design activity [Archer 1995]. In a *research through design* process, working prototypes are created from a clear research question and thus can express a hypothesis [Stappers 2007]. The prototypes are put to test in real-life contexts so users can experience them [Frens 2006]. The design solutions behind the prototypes can be based on research methods or theories. The prototypes ultimately become the instruments in experiments [Keller 2005], playing the role of stimuli in formal experiments [Stappers 2007]. Knowledge is generated by designing the artifact, by the artifact itself, and by the evaluations of use. The knowledge gained can later be generalized as design recommendations, theories or frameworks.

Another aspect of *research through design* present in this thesis is the fact that the act of designing is in itself a confrontation of various forms of knowledge, both formalized and experiential, which brings about new knowledge. This aspect of *research through design* emphasizes the exploratory nature of design research over the traditional scientific culture of evaluating by testing, which must be conducted following very specific directions.
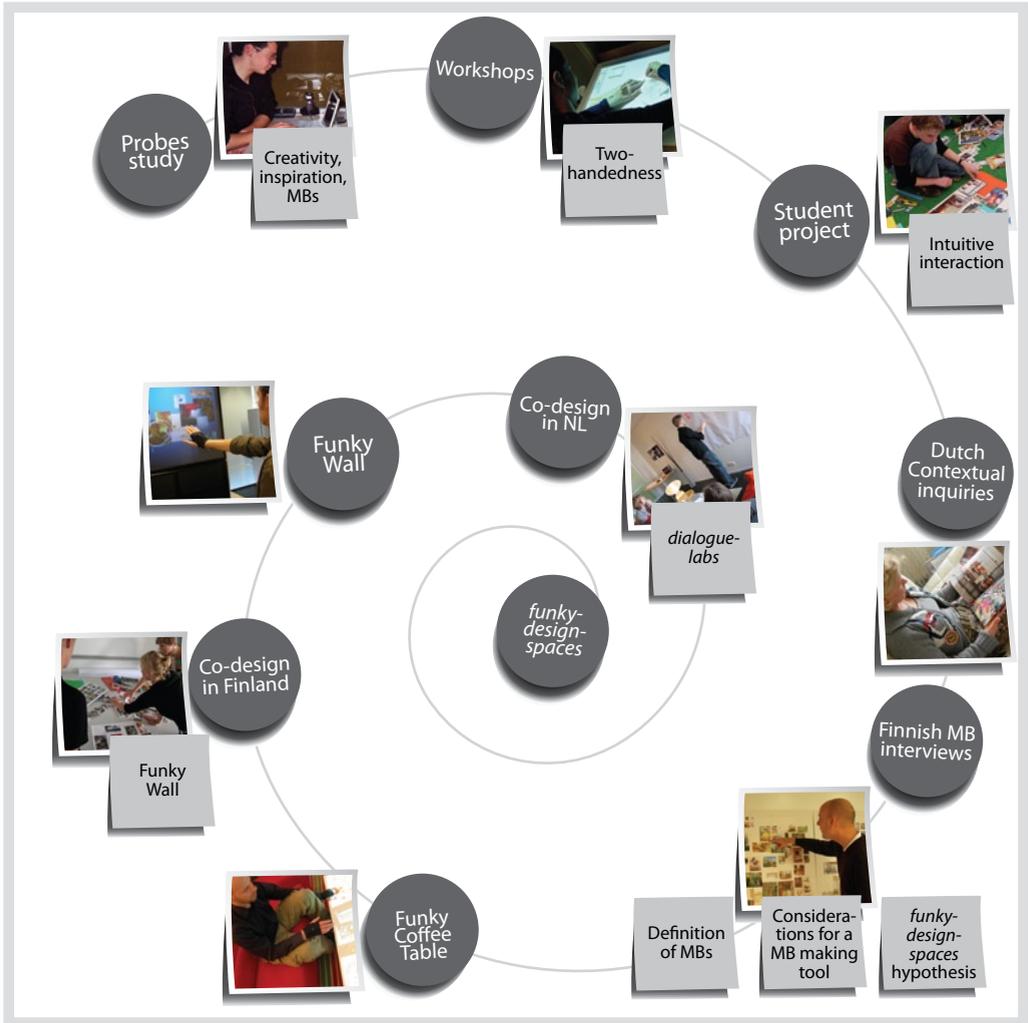
Figure 1. Research through design process

Field observations – Finding a focus in the probes, workshops and student project and later studying MBs

Co-designing concepts – Feeding our findings into co-design sessions in Finland and the Netherlands

Experiential tools – Integrating the knowledge gained in the Funky Coffee Table and Funky Wall prototypes

In my *research through design* process (Figure 1) the knowledge gained in field observations (chapters 2 and 3) is integrated with the co-designed concepts or *funky-design-spaces* (chapter 4) into experiential tools (chapter 5). The Funky Coffee Table and Funky Wall prototypes are created and later tested to express the *funky-design-spaces* hypothesis and to try to provide answers to my research questions on how and why designers create MBs and how AR tools can provide support for this activity.

My complete *research through design* process consists of 10 separate studies conducted with 50 (different) practicing designers and 32 industrial design students:

×   *A probes study with Dutch designers who identified MBs as a relevant topic.*

×   *Workshops with Dutch designers who encouraged us to augment mood boarding.*

×   *A student project where the concept of intuitive interaction begins to shape up.*

×   *Two contextual inquiry studies on Dutch and Finnish designers' use of MBs that helped identify requirements for an AR tool that supports mood boarding and integrate them into the funky-design-spaces hypothesis.*

×   *Co-design sessions conducted in Finland and the Netherlands to elaborate on my hypothesis and test the idea of constructing a space rather than a single tool that supports MB making with AR.*

×   *Two prototypes that were designed, implemented and evaluated (i.e. the Funky Coffee Table and the Funky Wall) to bring the funky-design-spaces hypothesis to life.*

×   *An extra evaluation of the two experiential tools running alongside each other to test the funky-design-spaces hypothesis.*

1.6   About this thesis

To avoid as much as possible repeating background information at the beginning of each chapter, this thesis is constructed as different chapters that build from one another. The different publications from the author that were originally written for different audiences and research communities (e.g. design research, tabletop interaction, general HCI) are thus modified for the benefit of communicating the larger picture in the entirety of this book.

The thesis follows a chronological order to give a sense of the process together with the specific activities undertaken. Throughout this thesis, other designers and researchers have contributed in preparing, discussing, co-designing, implementing, and inspiring this work. At the start of each chapter, their names are mentioned.

Some acronyms are used throughout the thesis:

×   *MB (mood board) – MBs (mood boards)*

×   *AR (augmented reality)*

×   *UCD (user-centered design)*

×   *HCI (human-computer interaction)*

First-person singular ("I", "me", "my") is used at the beginning and end of each chapter. At the beginning of the chapter first person is used to introduce the problem while at the end of the chapter it is used to reflect on the process. In these two parts of each chapter, references to the author's own experiences are included as illustrations of an issue regarding the research process. First person is not used to argue a solution or decision.

1.7   Outline of this thesis

In this chapter 1, the starting point for this research is described. Based on the context of the research and previous experience, an alternative approach is proposed and discussed. Finally, the main research questions are presented.

In chapter 2, design practice is studied by means of three studies to provide designers with a sensible AR support tool for their work. The chapter starts with the probes study where design activities are examined from a general perspective. From the probes study, a set of important ideas and possible research directions are deduced. The findings are connected to supporting creativity and finding inspiration in the early stages of the design process. Mood boarding is identified as a relevant task for designers and potentially becomes the central activity to support with AR. The chapter continues with the second study, workshops, where probes results are discussed with designers who are also confronted with an AR tool. In the workshops, designers see the potential of supporting mood boarding with AR and encourage us to do so. Finally, a student project is presented where the actual making of MBs is observed using different techniques such as traditional, digital and AR MBs. The concept of *intuitive interaction* begins to shape up.

Chapter 3 explores mood boarding in depth. An understanding of the essence of MBs is created by means of two studies. The results of both contextual inquiries with Dutch industrial designers and of MB interviews with Finnish textile and fashion designers are introduced. Based on these two studies, a definition of MBs, a detailed description of the MB making process and a summary of the five main stages of the MB making process are presented. The chapter ends by formulating the *funky-design-spaces* research hypothesis.

In chapter 4, the data from the previous two chapters is fed into co-design sessions with Dutch and Finnish designers. The general idea behind the *funky-design-spaces* hypothesis is tested in the *dialogue-labs* where researchers and people (i.e. designers) collaboratively come up with new concrete ideas that support MB making with AR. The idea for the Funky Wall comes directly from the co-design sessions and is explained in the next chapter. The *funky-design-spaces* hypothesis is initially proved true by designers and is put to the test with experiential tools in the next chapter.

Chapter 5 looks at AR tools and technology to further explore the *funky-design-spaces* hypothesis. Two tools, the Funky Coffee Table and Funky Wall are designed,

implemented, and evaluated. The knowledge and experience from the previous three chapters are integrated into these two working tools. The results of the evaluation prove the *funky-design-spaces* hypothesis true.

Finally, chapter 6 rounds off this thesis by reflecting to what extent the activities described in this thesis contribute to our understanding of the research questions, identifying aspects that could also be valuable to other researchers working in similar and different context than mine.

DESIGN PRACTICE

2 Design Practice

This chapter is based on the articles:

×   *Andrés Lucero & Jean-Bernard Martens (2006) Supporting the creation of MBs: industrial design in mixed reality. In Proceedings of TableTop 2006, IEEE, 127-128.*

×   *Andrés Lucero & Tuuli Mattelmäki (2007a) Professional Probes: A Pleasurable Little Extra for the Participant's Work. In Proceedings of IASTED HCI 2007, ACTA, 170-176.*

×   *Andrés Lucero, Tatiana Lashina, Elmo Diederiks & Tuuli Mattelmäki (2007b) How probes inform and influence the design process. In Proceedings of DPPI '07, ACM, 377-391.*

2.1 Problem

According to the original proposal of my PhD project ID-MIX: Industrial Design in Mixed Reality, I was supposed to investigate the impact and practical relevance of mixed reality (augmented reality or AR from now on) tools on actual work practice, with industrial designers as a specific user group. I had to first identify relevant tasks for designers and later design and evaluate alternative AR approaches in several design cycles.

A huge task lay ahead of me. First study design practice, identify a relevant task for designers, and really understand what are some of the difficulties and possible opportunities of moving to AR, not assuming that the tool will augment the activity *per se* because maybe it will de-augment some of the current features. The value would be in getting the grips of providing support with AR in a sensible way. To achieve this, I would have to spend a considerable amount of time talking to designers and understanding their practice. Although I would most probably run out of time at the end of the process that originally included several design cycles, I was more than happy to compromise this aspect to make sure that the tools I would create make sense to users.

2.2 Related work

Several researchers have studied design practice in different disciplines (e.g. industrial, fashion, graphic, etc.), countries, and focusing on specific stages of the design process. Eckert and Stacey [2000] did an empirical study with knitwear designers to facilitate communication within design teams with computer support. Over seven years and in three different countries (i.e. Britain, Germany and Italy), they looked into the use of sources of inspiration throughout the knitwear design process. As a general finding, they identified the important role that previous designs and other sources of ideas (i.e. shapes, patterns, motifs and color combinations) play in defining the context for new designs and in informing the creation of individual designs.

In the Netherlands, Bekker [1995] interviewed sixteen interface designers to determine the type of support they need for gathering information about users and applications in the design process. Regarding the main findings, designers requested support tools to improve user involvement in design projects, communication and prototyping activities. Some of the problems encountered by interface designers to gather information from users and their tasks were: not knowing what methods to use and the infrequent contact with users. In relation to design practice, Bekker's findings refer to different aspects behind the project teams such as how the teams are configured, how team members collaborate, how information is gathered, problems encountered by the team, and the tools used along the project.

In an attempt to provide real-world supportive tools in the form-creation phase, Kolli and Pasman did research on the designers' work environment by conducting six contextual inquiries with creative professionals (i.e. photographer, fashion designer, sculptor, potter, jewelry designer and furniture designer). They summarized their observations into general findings that are applicable to design practice in different areas. The main areas of interest referred to the participants' background and experience, projects and clients, methods and techniques, tools, work environment and an ideal computerized environment. Kolli and Pasman [Kolli *et al.* 1993] elaborated further on this study by conducting contextual inquiries with eight practicing industrial designers, focusing on form creation and development in the product design process. They clustered their observations into seven considerations for designing a computer environment that supports conceptualizing. Such tools should: 1) support the rapid and rough capturing of ideas; 2) afford a personalized environment; 3) use rich information sources; 4) enable a high level of communicability; 5) support individualistic styles; 6) afford a smooth shifting of activities; and 7) support motor skills. As a general conclusion, they pointed out the importance of visual material and visual ways of working in the conceptualization process, relying heavily on existing designs as input for their idea generation. Designers collecting precedents in the form of product samples, product catalogues, photographs or slides becomes a major activity during the conceptual phase. Designers later process these samples into collages, MBs or presentations [Pasman 2003].

In a follow-up of the 1993 study by Kolli *et al.*, Keller *et al.* [2006] specifically looked into the way product designers keep and use their informal collections of visual material (i.e. advertisements, magazines, and pictures) in their design process and to provide new media tools that support these interactions. They used cultural probes [Gaver *et al.* 1999] and conducted five contextual inquiries with practicing product designers. Most of their findings were in line with the 1993 study. The main differences were the emergence of Internet and the divide between the digital and physical worlds. Regarding the latter, they found out that the designers' digital and physical collections were hardly ever used in combination. Their results were also

input for a set of six considerations for a tool to support designers in collecting visual material, trying to focus on merging both collections in interaction and value. The tool should: 1) support active collecting without a predefined structure, 2) merge physical and digital collections, 3) rely on visual interaction, 4) enable serendipitous encounters of material, 5) provide inspiration by breaking the working rhythm, and 6) support social aspects of visual material.

2.3 Probes study

2.3.1 Problem

Several studies of design practice have been conducted in different countries such as Sweden [Gedenryd 1998], England [Eckert & Stacey 2000], Finland [Valtonen 2007] and Australia [Tang 2001], to name a few examples. In the Netherlands, where this study took place, researchers have studied design practice in terms of the creative work environment [Kolli *et al.* 1993] and on how designers find inspiration [Keller 2005]. We wanted to study how Dutch designers work in order to look for trends and identify opportunities for AR to support their work. As such, in this first study, we needed to identify representative activities that industrial designers perform. Therefore, our first research question was *do industrial designers see opportunities for AR to support their work, and if yes, how?*

2.3.2 Approach

To find answers to the previously mentioned research question, we had to enter the design studios and study how designers work to identify activities that could be supported by AR. We decided to use a non-intrusive method that would allow us to obtain information from the participants while working in the real context (i.e. their design studios). We used cultural probes [Gaver *et al.* 1999] to get an idea of the details behind designers' lives: what designers do in the design studio, their activities, places and objects they use in the practice of industrial design (Figure 2). In this part of the study, participants were also asked on their current use of technology and on their familiarity with AR.

2.3.3 Participants

Seventeen practicing industrial designers were initially recruited for this study. They all agreed to participate in the study although ultimately only 10 worked on the probes and sent them back. Three of the final participants also worked in design research and design education. All participants had at least 2 years of experience in design practice (9 years of experience on average). The participants varied in their education (university, academy), age (between 24 and 50), and gender (6 male, 4 female). We obtained a wide variety of contexts, ranging from an office in a large

company, to freelance work performed at home. We also wanted to see how designers work in contexts other than their offices. Therefore, we included practicing industrial designers who spent one day per week coaching industrial design students at our university. In this way, we were able to see how designers organize their work in two different workplaces.

2.3.4 Method

The basis for this user study was the cultural probes method [Gaver *et al.* 1999]. Design and research practitioners have applied probes in their design processes to find new ways of understanding user experience, allowing them to obtain a better understanding of their users and to inspire their designs. Regarding its main characteristics, probes: 1) are based on user participation by means of self-documentation, 2) look at the user's personal context and perceptions, and 3) have an exploratory character [Mattelmäki 2006]. Therefore, they are also very useful for experience research in which possible areas for new applications of technology are explored from a user perspective [Diederiks & Kyffin 2006].

Gaver, Dunne and Pacenti first introduced cultural probes [Gaver *et al.* 1999] as a form of exploratory and design-oriented self-documentation method. Cultural probes are collections of evocative tasks meant to elicit inspirational responses from people – not comprehensive information about them, but fragmentary clues about their lives and thoughts [Gaver *et al.* 2004]. A probe kit is given to volunteers representing the group that is being studied. The contents of the probe kit differ from one design or research project to another. Probe kit materials are purposefully ambiguous, trying to stimulate the mind of the participants and capture their experiences while working on the probes. No hard deadlines are imposed on participants who do these assignments in their own time and natural environment allowing them to feel at ease and relaxed. Participants complete the materials and send them back to researchers for interpretation. One of the advantages of working on probes over extended periods of time (e.g. one week) is that it allows participants not only to reflect on the topic that is being researched but also on the answers they have provided on the previous days [Lucero *et al.* 2004].

Several researchers have extended probes for different contexts and uses, such as in technology probes [Hutchinson *et al.* 2003], mobile probes [Hulkko *et al.* 2004], empathy probes [Mattelmäki & Battarbee 2002], photograph probes [Nieminen & Mannonen 2005] and urban probes [Paulos & Jenkins 2005]. These variations on probes have opened a vast space of new opportunities for design and research. These opportunities include informing design, facilitating the process of design reflections, and the framing of the problem solution space [Mattelmäki 2006]. However, Gaver has identified that in the process of adapting probes, some researchers have also appropriated the probes into a scientific process [Gaver *et al.* 2004]. Gaver is skepti-

cal about this growing tendency to rationalize an approach that originally values uncertainty, play, exploration, and subjective interpretation.

In an industrial context, the objective of using resources for probing is based on the expectation of improving the solution creation and decision-making processes. Thus, usually in design practice and in research, project leaders and managers expect to see one *ultimate* and well-argued solution emerging as a result of probing. Apparently, when presenting the results from probing together with the final design you should be able to draw a straight line between them and verify the value of the resources used. This expectation makes sense, since often the aim is to bring a product proposition to the market as fast as possible. This is usually done for a defined target market requiring only very specific user or market research.

However, if we want to embed our solutions in social and material contexts (a design perspective) or if we want to generate more than one option for possible applications (interaction, experience and application research) the aim is to explore the broader context as well. In most cases a direct connection between probes results and the final design is not evident as probes inform and influence the design process in many different ways. Based on a study that applied probes in the context of the bathroom for a lighting system, Lucero *et al.* [2007b] considered the links between the probing results and the final design solutions and demonstrated their relationships. We found that the use of probes allow designers to 1) enter an intimate space, 2) discover unexpected uses, 3) gather requirements, 4) look into participants' lives, 5) shift focus, and 6) find inspiration for new concepts. The authors emphasize the idea that design and research teams should not be expecting a single or ultimate result emerging from probes. Instead, probes usually provide a wide range of potential ideas leading to other possible solutions. The final chosen solution will depend on the skillfulness of the design team to translate the findings into a final concept.

2.3.5 Procedure

Ten Dutch designers worked on the probes and took part in the study between November 2004 and June 2005. Participants worked on the probes in their design studios and homes for a period of one week. We wanted to observe industrial design practice, not only the activities, places and objects used, but also we were interested in more inspirational data. The probes study consisted of four parts: making the probes, sending the probes, working with the probes, and collecting the probes.

Making the probes

We describe our probe kit using Mattelmäki's properties of probe objects [Mattelmäki 2006]. First the kit contained a design-studio diary including 1) a timeline to probe the daily thoughts and activities of our participants (Figure 3, bottom), 2) closed questions covering different aspects of routines, collaboration, and use of

Figure 2. Aspects of the probes study

The probe kit (top-left) – Consisting of a design-studio diary with activities and a disposable camera

Probing design practice (top-right) – A designer's workplace

Probing people's lives (bottom-left) – The probes also allowed us to look into the designers' lives

Probing experiences (bottom-right) – Collection of over 200 images made by 10 participants

technology, 3) open questions to make people tell stories and express their opinions (Figure 3, top-left), 4) a map to allow self-expression, and 5) a drawing exercise (*ideal design studio*) to probe the dreams and aspirations of industrial designers. In the map exercise, we first asked participants to cluster their activities, places, and objects used for their work (Figure 3, top-right). Then we asked them to draw a floor plan of their design studio and link their daily activities to the objects and the places on the map. In the *ideal design studio* drawing exercise, we asked them to forget about budget, organization or other restrictions and share with us what their dream design studio would be like.

Second, the kit included a disposable camera to take a maximum of 36 pictures to visually support some of the experiences they had while working on the probes (Figure 2, bottom-right). We included a table in the design-studio diary where participants kept track of their pictures. We made suggestions for shots as well as intentionally left half of the pictures unassigned so participants could share different aspects of their environment or activities with us. In total, participants made over

200 pictures with the disposable cameras (21 pictures per participant on average).

A considerable amount of work and resources was destined to create an inspiring probe kit. The design-studio diary was designed with great care so that designers would appreciate it was handcrafted and especially made for them. Upon receiving the materials, designers had very positive comments and reactions. Participant SK said, *"This is so nice. It really looks and feels like a diary."* The booklet was designed to visually stimulate writing. A handwriting-like font was used to communicate directly to our participants' heart and to trigger an intimate sharing of their experiences while filling-in the diary. A blue color was used for the text to further elicit that it was handwritten with a ballpoint pen. We were successful in conveying this aspect to designers as two participants asked us, *"Did you write this down manually?"* The effort put in designing the probes was rewarded by the participants' dedication to work on the probes. The content of each probe kit was packed in a brown envelope to further elicit a down-to-earth and handcrafted feeling.

When planning the probes we also took into account the nature and context of the work we were going to study. We especially looked into the placement of the probes, in other words, where and how designers would most likely use them. To create less mess on the sometimes-cluttered desks of designers, we concentrated most probe materials into one booklet.

Sending the probes

To increase motivation, all participants were given the probe kit (Figure 2, top-left) during a personal meeting. For five participants this meeting took place in their design studio. The remaining five participants received the probe kit during the kick-off meeting of Young Designers in Industry (YD+I) that took place in February 2005 in Amsterdam. YD+I is a foundation where industry and public institutions act as problem owners of extremely complicated social and cultural problems, that young creative designers must tackle head on. Kees Dorst, one of the organizers of YD+I, was our contact and gave the probe kit to the participants.

All participants signed a consent form in which their anonymity was guaranteed and allowing us to use their comments and suggestions for research purposes.

Working with the probes

Participants worked with the probes for seven consecutive days in their design studios and they could freely choose the starting day of the week. The materials included in the kit probed different aspects of the life (Figure 2, bottom-left) and practice (Figure 2, top-right) of an industrial designer.
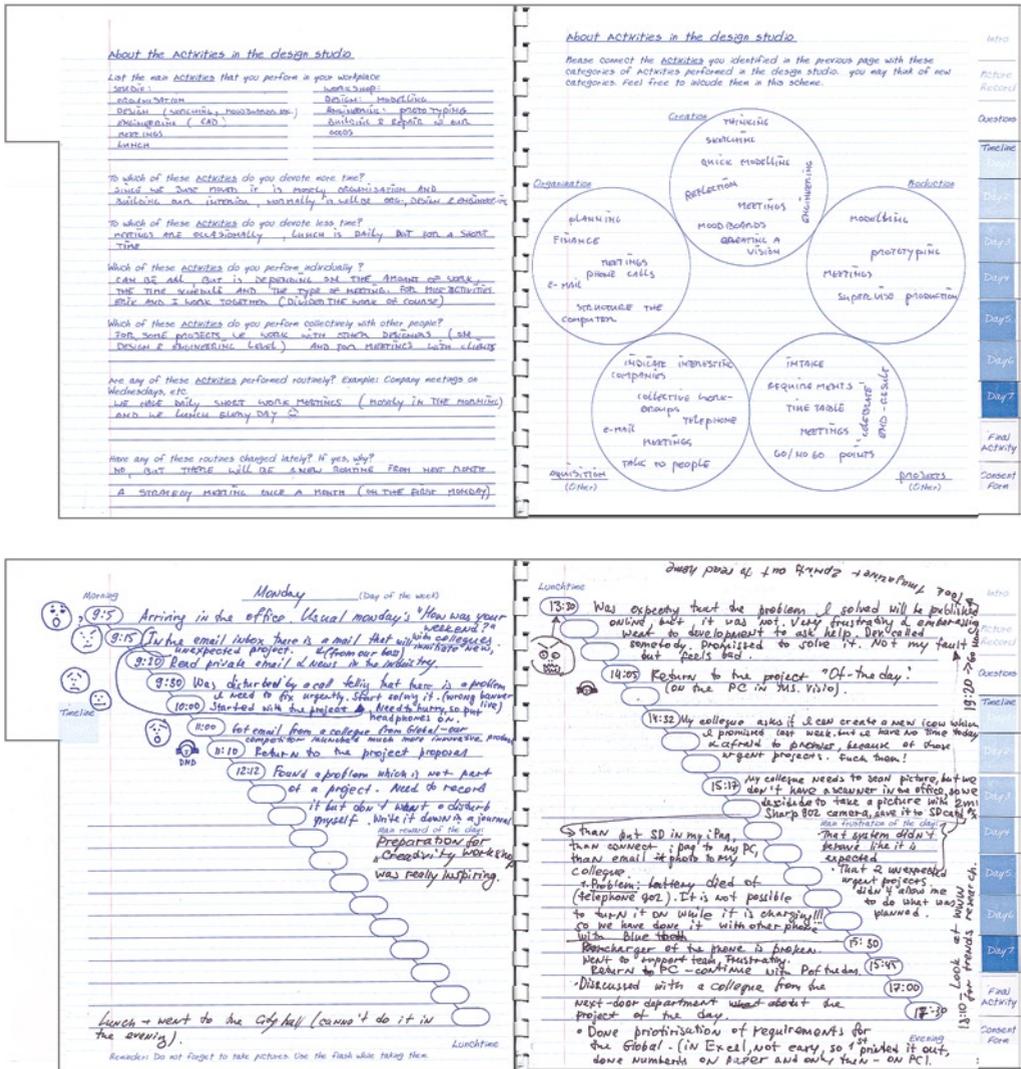
Figure 3. The design-studio diary

Closed and open questions (top-left) – Covering aspects of their activities and leaving room to express their opinions

Clustering (top-right) – Participants grouped their main activities according to suggested categories. The bottom two categories were intentionally left blank for them to complete the diagram

One-day timeline (bottom)– Designers shared their daily thoughts and activities by filling-in seven timelines. The left part corresponds to the morning and the right to the afternoon. Tabs were created to help participants find the current day of the week

Collecting the probes

For the first five participants, we picked up the probe kits in their design studios after one week. The other five YD+I participants sent their probes by mail in the self-addressed and stamped envelopes we included in the kit.

2.3.6 Interpretation

Once the probes kits were collected, the data was processed for interpretation. The data from the diaries for all participants was transcribed and comments were number and color-coded for each participant. Tables with the participants' entries were created as a way to have a clear overview of the rich data that had been collected. The pictures from the disposable cameras were developed and scanned as they provided information on the written content of the probes. Two researchers (Selene Mota and the author) went through the data and derived categories from the users' data. General findings were formulated and presented back to the participants for discussion during an interview to check the reliability of the interpretation.

2.3.7 Checking the interpretation

Participants were invited for probing interviews [Mattelmäki 2006] to check the interpretation made by the researchers. These personal interviews were held as part of larger workshops that were organized to introduce the participants to AR technologies in our research lab. Unfortunately, only four of our original probes study participants were able to attend the workshops. We decided to present our general findings anyway to the remaining six participants by means of visuals for discussion, as they were also industrial designers and thus familiar with the topics that were presented. The workshops are explained in greater detail in the next section (2.4).

2.3.8 Findings

In general, our findings are connected to the early stages of the design process. As such, our main findings can be divided into 1) supporting flexibility in creation, 2) finding inspiration, and 3) mood boarding.

Supporting flexibility in creation

As industrial designers reach the late stages of the design process, they require a higher level of detail and control over their work, relying heavily on their computers. However, during the early stages of the design process, designers need tools that allow more flexibility, especially during the creation phase. Most activities mentioned in the diary in relation to this creation phase (i.e. designing, thinking, creating MBs, contemplating, inspiration, sketching, brainstorm and discussing) do not require a computer. Workshop participant ER said *"the design process starts with the generation of ideas which is done away from the computer."* JJR added, *"people are*

Figure 4. Flexibility in creation

Sketchbooks (top) – The most important objects for two participants: their pencils and sketchbooks

Flexible uses of office space (bottom) – Using the floor to conduct a brainstorm session and designing at an elevated table in a standing position

making a strong link between designers and computers; however, twenty years ago we did not have computers to design. Computers should be mainly for visualization, presentation and communication. The designer-creator does not work in front of the computer."

Designers stressed the importance of working with their hands in the early stages of the design process. In the creation phase, designers prefer the naturalness of using pencils and paper. Designers keep a sketchbook at hand to make notes and bring their ideas to life (Figure 4, top). Participant FV told us just how important sketchbooks are to him: *"I make a sketchbook with everything in it where I draw and paste stuff. For important projects I keep a special (dedicated) sketchbook."* Although not all designers keep a sketchbook, participant MM explicitly mentioned he missed the feeling and the pleasure of using pen and paper to shape his ideas: *"Pens and pencils are the most important objects for me although I use them so rarely now to design (due to time constraints), but it is the nicest thing to do."* Participant SK told us why she prefers using her hands over computers for creation: *"Whenever I am molding or looking for new shapes, I know I can easily change colors and rotate the models on the computer but you miss the feeling (of rotation) with the mouse."* She wanted to have the feeling that she was molding with real paper.

The relationship between designers and their use of technology is a special one. They all accept technology, have incorporated it in their lives, and feel they can manage with it. Most designers use a computer both at home and at work, have a mobile phone, and some own a personal digital assistant (PDA). In spite of this, designers see technology as a means, something necessary for their work, but not as a goal. Designers especially show some concerns regarding the role that computers play in their creative process. Designers feel that computers may be taking away part of their creativity especially in the early stages of the design process as can be told from this comment from participant MM: *"I don't want to get too close into computers as they might interfere with the creative design process."* As we see, although in most cases designers see technology as something necessary, useful, and essential for their work, designers will use technology only if it matches the way they like to work. Technology should adapt to them, not the opposite. This comment written by AG in her diary tells us they will accept technology only if they feel comfortable with it: *"I never thought that I would use computers when I first tried a PC with DOS. It was so unnatural that I hated it. Now I love my computer. It helps me solve my greatest annoyance: the untidiness of my drawings."*

Designers use their work environment in flexible ways (Figure 4, bottom). They may have vertical separation panels to which they attach images or sketches. Depending on the environment, designers may use a meeting table not only to hold internal and external meetings, but also to serve on occasions as a place for creativity or to have lunch. For designers who perform freelance work at home their dinner table may become the meeting table. Kitchens, coffee corners and a bar inside the design studio were mentioned as important places to have a break, to socialize, for relaxation, and have *ad hoc* meetings. This flexible use of space should also be encouraged when supporting the work of designers with new technologies.

Designers do not want to be tied to their computers. They requested flexibility to design outside the office, to work outdoors in the sunshine, to take their laptops to the forest. As participant SK nicely put it: *"I search for ways to work that do not drag me to my computer time and time again."* Allowing for this type of flexibility in relation to the environment when designers are engaged in creating should be encouraged.

Two ideas emerged from the *ideal design studio* activity. In the first one (Figure 5, left), participant SK proposes an open space where technology (camera, writing pad, projector, modeling programs) is integrated in the walls, floor and ceiling so designers can create impulsively with different tools, having both freedom of movement and space at the same time. Quick physical models can be made on a small toolbox or table. In this idea there are no traditional desks or desktop computers allowing designers to create on a larger scale making use of the full space. SK told us: *"Design through movement supports an energetic way of working, away from the world of (desktop) computers."* In the second idea and in relation to using their work environ-
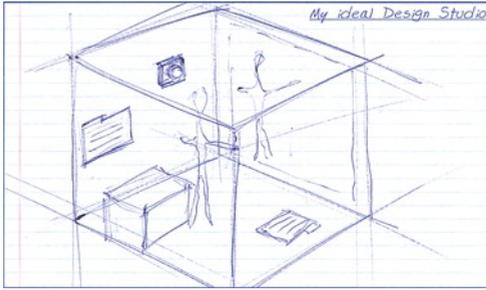
Figure 5. Ideas on supporting flexibility in creation from the diaries

An open room (left) – Using the full available space in the design studio to freely create

The messy desk (right) – A visual reminder of ongoing projects

ment in flexible ways (Figure 5, right), participant SM proposes the messy desk. In this example, the designer manages and has an overview of his projects by having two separate desks: a clean desk to work on and a messy one to keep an overview of his projects, something like a to-do list. Participant SM described it in this way: *"A desk to store 'work in progress' is as important to me as a (second) clean desk to work on. The 'work in progress' desk serves as a dustbin and a physical overview of my to-do list. It helps me to keep overview of eight to fifteen different projects simultaneously."* By keeping messy stacks on his desk, he knows exactly what has to be done in each single project. This proposal raises some questions: how would designers manage and keep such an overview of their projects in an augmented desk? Would this be an opportunity to easily carry their virtual mess from one place to another?

Finding inspiration

Finding inspiration is another important factor for designers and they have different ways to achieve this. In their diaries, participants were asked to group their activities according to categories that were either predefined (i.e. *creation, organization, production*) or two categories that were left blank on purpose. While some participants included the act of finding inspiration as part of the *creation* category, for others inspiration was such an important activity for their work that they labeled one of the blank categories with it.

Most participants reported that finding inspiration was very much related to forgetting about work for a while and being able to approach design problems from a different perspective with a fresh mind. Participant JJR said, *"Inspiration is related to a state of mind which can be achieved in different ways."* Designers have their own special ways of being inspired. For some, inspiration may come from browsing magazines, reading books, surfing the Internet or visiting fairs (Figure 6, top). For others it may be connected to meeting or observing interesting people. ER mentioned, *"You*

can talk to people who inspire you." AVS added, *"(You can find inspiration) listening to real people discussing their problems on the train or tram."* Having short breaks to perform physical activities both inside and outside the design studio is one of the strategies used by designers to find inspiration. Inside the studio, designers mentioned a pinball machine, a darts board and a painting corner as examples of physical activities for inspiration. Outside the office, designers find inspiration by thinking about a project while walking in the park, walking their dog, riding their bike, doing shopping, or going swimming. Participant FV told us, *"I go out cycling to break away from my strict thinking pattern."* SK mentioned that, *"you can go out for a walk, going for action."* AO pointed out that she would find inspiration while *"summarizing the day on the way home by bike and/or train."* Participant JJR's diary revealed he had two short breaks playing football first indoor and then outside on a same given day (Figure 6, bottom). The point is that all these activities were performed during working hours. Designers either choose to think about a project from a different perspective while performing these activities or rather prefer to clear their mind and come back to the problem at the office.

Designers traditionally arrange their studios in ways that inspire them. They put up boards on the wall to stick inspiring pictures and printouts from projects. They also have bookcases where they keep their magazines and store books. Participant JM asserted, *"Sometimes things on the wall, or little sketches left behind by others can be a source of inspiration"* (Figure 6, middle-right). Designers also mentioned the importance of having a special place within the studio where they are able to relax, maybe even meditate inside their workplace. For designers who work at home, their place to think about a given idea could be their living room or, as participant EP mentioned, *"laying in bed with my notebook to think and write down a project"* (Figure 6, middle-left). In some design studios, designers have a dedicated inspiration corner where they can disconnect from work.

As was previously mentioned, some twenty years ago in old practice designers spent most of the time designing standing up in front of their drawing boards. This configuration was much better suited for having *ad hoc* discussions, presenting and sharing ideas to others, which encouraged physically moving around the studio. Managers knew exactly when it was a good time to approach a designer based on the designer's location within the design studio or the position of their drawing board (e.g. horizontal for work, vertical for presentation).

Another key aspect for designers to create an inspiring atmosphere inside the design studio relates to observing the outside world. Designers want to be able to have a clear view to observe and be in close contact with nature. Emphasizing the importance of nature for designers, participant SM pointed out, *"I use my laptop virtually everywhere including the nearby forest."*

Figure 6. Finding inspiration

Traditional sources of inspiration (top) A corner with books, magazines and materials, and bookcases with

magazines and books. MF says, *"I like my books very much for motivation and inspiration."*

Inspirational place (middle-left) – Laying in bed as a way to think differently about a design problem

Inspiring environment (middle-right) – Posters, sketches, and snippets left behind by colleagues can also inspire

Inspiration through physical activity (bottom) – Having a short break to play football indoors and outdoors

In relation to finding inspiration, two ideas were mentioned in the *ideal design studio* activity. The podium (Figure 7, left) was described by participant JJR as *"an elevated platform close to a very well lit area with large windows where we (designers) can sit in an informal way. It has a different energy field."* Physically walking to the podium makes designers go away from their computers, take a step back and reflect on what

Figure 7. Ideas on finding inspiration from the diaries

The podium (left) – Going to this elevated platform makes designers leave their computers. It is a special place with a *"special energy field"* to start creating

Natural spaces (right) – Having a greenhouse as a design studio to be in close contact with nature, be able to design in the forest and collaborate with colleagues from different disciplines

they are doing. In this studio the podium is used as a place where industrial design-
ers meet to brainstorm. Having a special place that designers have to walk to in order
to start brainstorming or design is a potential interesting idea to stimulate physical
activity. For the second idea, participant SL proposes reusing an ancient greenhouse
by a park where several designers have their own space or box (box within a box
concept) to work in and store things (Figure 7, right). The main ideas behind this
proposal are the proximity of natural scenery and sharing the greenhouse with
other designers, artists and professionals related to the world of design in a modular
system. Its creator said, *"Currently I am literally trying to create with the city council a
greenhouse in a park as my own design studio to stress the relation with nature that I have
as a designer."*

Mood boarding

Most designers mentioned MBs as an important activity for their work. One
designer described herself as a MB designer and kept special magazines to use for
her MBs (Figure 8). Participant AVS summarized what MBs represent for designers:
*"it is a representation of a feeling or direction you want to go. It is not hard words about
what you will do, it is emotional, a softer way of giving directions to your design, with
reference points, sometimes colors or shapes. You can later verify whether what you are
doing matches the mood you created in the beginning."* Regarding why designers use
MBs SM said, *"whenever you want to share your ideas about a project, it makes it easier
to express your feelings and see what the client's feelings are."* FV told us that by mak-
ing MBs *"it makes clients feel that you are producing already."* Participant ER added,
"Clients love them because they can already visualize what you are doing."

Designers make traditional (physical) MBs with images from magazines as well as digital MBs in Photoshop®. They start creating them by looking for images on the Internet, mainly on Getty Images or Google. Other designers said they used personal pictures made on their digital cameras or added some abstract drawings for the background. Regarding the abstraction level of the elements that go in a MB, participant FV said *"images should be abstract because otherwise clients get sucked in by the images and the idea could become too final."*

2.3.9 Conclusions

From our probes study, we have identified a set of important ideas or possible directions for supporting the work of industrial designers with AR.

Supporting flexibility in creation

Introducing technology to support creativity in the early stages of the design process should take into account several factors. First, working with their hands is very important to designers, especially in the early stages of the design process. As such they do not want to lose this basic, simple and natural tool as the main source of input for these types of activities. Second, designers see technology as a means, not as a goal. Work related to creation in the early stages of the design process is mostly performed away from the computer. When creating, designers prefer more flexible and intuitive ways of interaction, such as the use of pen and paper. Third, designers need tools that provide flexibility while creating and this includes their workspaces. Designers explicitly requested more freedom to decide how and where they work. They do not want to be constantly tied to computers or physical spaces.

Finding inspiration

Finding inspiration is an important aspect for designers. Designers have different ways of finding inspiration, which is very much related to forgetting about work for a while and being able to approach design problems from a different perspective with a fresh mind. Having short breaks to perform physical activities both inside and outside the design studio is one of the strategies used by designers to find inspiration (e.g. playing darts or football at the office, taking a bicycle ride in town, or walking the dog). Their design studios are also arranged in ways that inspire them with special places to stick images on the wall, keep their collections of magazines, or just to relax for a while. Having a view on the outside world to observe people and life also creates a nice atmosphere in the design studio.

Mood boarding

The creation of MBs was an unexpected or surprising finding from this study. Surprising because being a trained graphic designer I only became aware of the

Figure 8. Mood boarding

Magazines to make MBs – Designers keeping a special box with magazines for making MBs with them, and bookshelves filled with magazines

existence of MBs when I arrived in the Netherlands. The fact that designers in our study mentioned it as an important activity for their work only increased my curiosity. Our industrial design students at the TU/e were using MBs but there was no formal course or expert to consult on the topic. Mood boarding was something that students simply have to do. I was curious at this point how our participants were taught mood boarding in their universities or academies.

We made an initial assessment of the previously mentioned three possible directions for AR to support the work of designers, including some of the specific ideas (i.e. open room, podium, messy desk, natural spaces, having short fun breaks). All these alternatives were carefully considered and analyzed first with respect to the importance for the design process or that designers regard them as potentially interesting because they help avoid current problems or create new opportunities. Other aspects considered at this stage were connected to which areas, topics or activities have not been explored closely up to now. For example the creation of MBs seemed to be an important activity for designers that had not been sufficiently studied, thus increasing the likelihood of leading to publications. We also considered the technical and theoretical expertise needed to bring some of these ideas to life. Finally, we analyzed these ideas with respect to the areas of research that they covered (e.g. tangible, tabletop or gestural interaction).

At this point in my research, mood boarding seemed like a good activity to support with AR. Somehow MBs summarized most of the findings from the probes study. MBs are mostly created in the early stages of the design process, specifically in the creation phase, and respond to the need of designers to create away from the computer. MBs provide a similar type of flexibility for designers at this stage of the design process as pen and paper. MBs are also connected to the physicality mentioned by our participants for inspiration. For example, mood boarding away from

the computer bares some similarities with the painting corner mentioned by one designer as a special place for inspiration. Using their bodies to physically walk to a corner and start using their body in a more active fashion than while seated behind the computer is something that both painting and mood boarding share.

2.4   Workshops

2.4.1 Problem

Our first research question was *do industrial designers see opportunities for AR to support their work, and if yes, how?* We took the first step to answer this research question by conducting a probes study in which we identified a set of representative activities and ideas that could potentially support design practice. First, we needed to check the reliability of our interpretation by discussing in more detail the general findings of the probes study with our participants. Second, we wanted to involve designers in helping us decide which of the previously identified activities and ideas had a better potential for support in AR. However, just like any other professional user, industrial designers were not familiar at the time with what AR exactly was. Therefore, third, we needed to give them some examples of what AR is before we could finish answering our first research question. The main research question for the second study was *which of the activities or ideas identified in the first user study could potentially be supported with AR?* and more specifically, *should mood boarding be supported by AR?*

2.4.2 Approach

To find answers to the previously described questions, we invited designers to participate in interactive workshops in our research lab at the Eindhoven University of Technology, the Netherlands. These workshops would allow us to further empathize with our participants by first discussing our findings from the probes study with them, by giving them a presentation on what AR actually is, and by sharing and letting them experience some of the work done in our lab. These activities would ultimately stimulate the participants' imagination in a brainstorming session where new, creative, and unexpected applications of AR for industrial design practice would be discussed.

2.4.3 Participants

Originally, we intended to have the same 10 participants from our probes study participating in the workshops. For different reasons, only four of them were able to attend the workshops. We invited six new participants who agreed to take part in the workshops. They were all practicing industrial designers. One of them worked in design research and design education. All participants had at least 2 years
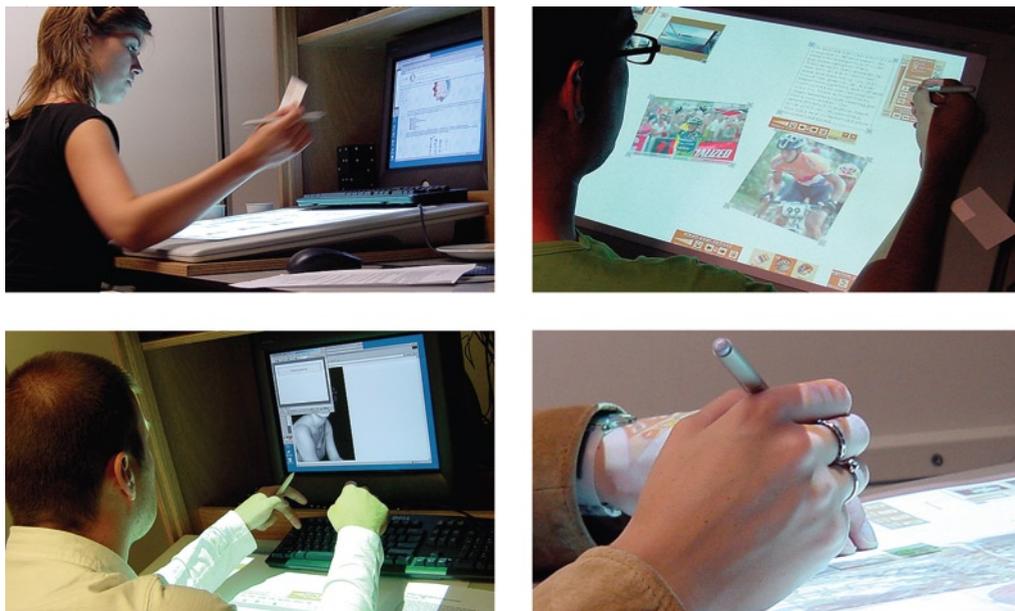
Figure 9. Workshop participants creating a MB using an AR system

The user experience (top-left) – Vertical screen for Internet browsing plus horizontal workspace for building the MB

Horizontal workspace (top-right) – Digital pen and cards with reflective material to interact with the system

Vertical screen (bottom-left) – Using mouse and keyboard input to browse images on the Internet

Interacting with the digital pen and card (bottom-right) – Digital pen and card with reflective material

experience in design practice (5 years of experience on average). The workshop participants varied in their education (university, academy), size of the agency they worked for (from one-man freelance designer to a design department of a large department store), age (between 24 and 31), and gender (7 male, 3 female).

2.4.4 Procedure

Ten workshop sessions were carried out between August 3 and September 22, 2005 at the Eindhoven University of Technology (TU/e). Each workshop session was planned for two hours. The workshops consisted of four parts: 1) presentation on AR (20 min.), 2) probing interviews (20 min.), 3) experiencing an AR system (60 min.), and 4) brainstorming session (20 min.).

Presentation on AR (20 min.)
To introduce the main topic of the workshop we showed our participants a 20-minute PowerPoint presentation on AR. The presentation also gave us the opportunity
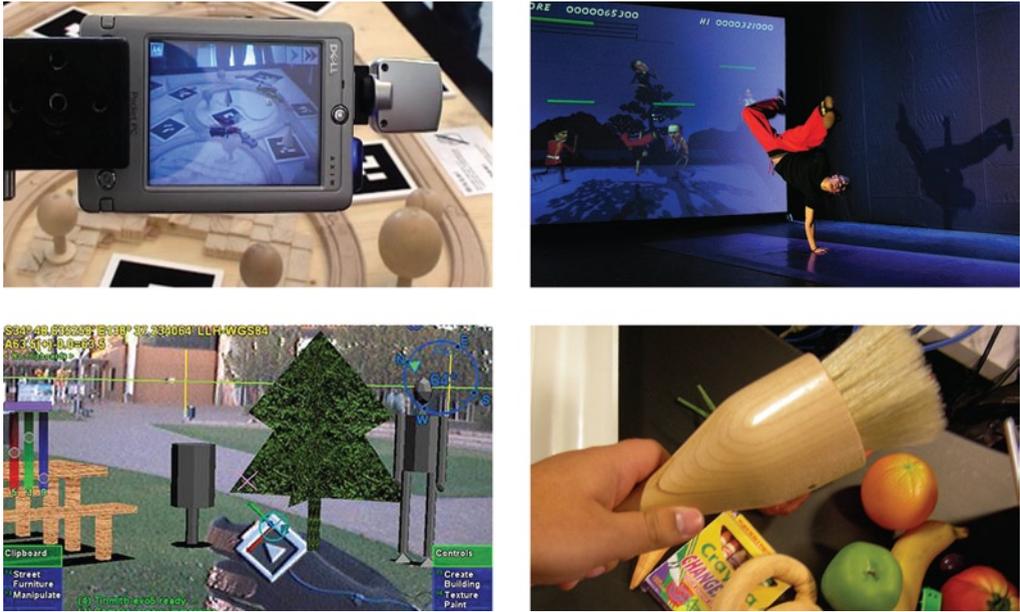
Figure 10. Examples of state-of-the-art AR systems shown to our participants during the workshops

The invisible train (top-left) – Magic lens metaphor using a handheld display, camera and markers

Kick Ass Kung-Fu (top-right) – Full-body interaction using computer vision and projection displays

Thumbs Up (bottom-left) – Head-mounted display and glove-based interaction for outdoor systems

The I/O Brush (bottom-right) – AR tool that allows painting with real-world elements on a digital canvas

to explain to our new participants the purpose of our research, say something about the previous probes study, and why we were organizing these workshops. The topics covered in the presentation included display technologies, interaction techniques, commercial applications, and application domains. Participants were shown representative examples of state-of-the-art along the mixed reality continuum [Milgram & Kishino 1994]. The videos shown were The Invisible Train [Wagner *et al.* 2005], Kick Ass Kung-Fu [Hämäläinen *et al.* 2005], Thumbs Up [Piekarski 2004], and the I/O brush [Ryokai *et al.* 2005].

First, The Invisible Train [Wagner *et al.* 2005] (Figure 10, top-left) was presented as an example of handheld display technology. Using a personal digital assistant (PDA), four users simultaneously play a cooperative game where the main task is to steer virtual trains over a real wooden miniature railroad track while keeping them from colliding. This was a good example of a simple and intuitive interface for an AR game. Second, Kick Ass Kung-Fu [Hämäläinen *et al.* 2005] (Figure 10, top-right) was presented as an example of projection display technology. In this martial arts

game installation, players fight virtual enemies. The players are captured performing kicks and punches in the real world and are embedded by the system into the gaming environment. The result is projected on two large displays. This was a good example of full-body interaction for a gaming system. Third, Thumbs Up [Piekarski 2004] (Figure 10, bottom-left) was presented as an example of a glove-based user interaction technique for mobile and outdoor systems as well as an example of using head mounted displays. In this system created to support architectural design, users can place virtual objects in the real world, interacting by means of pinch gloves. The Thumbs Up video nicely illustrates the pinch glove interaction technique as well as some of the possibilities for mobile AR systems. However, this video is also an example of bad user interface design in terms of overloading the display with unnecessary data (e.g. frames per second, coordinates in degrees, minutes and seconds, etc.). Finally, the I/O Brush [Ryokai *et al.* 2005] (Figure 10, bottom-right) was presented as an example of AR applied to arts and design, and thus was the closest example to the domain of industrial designers. The I/O Brush allows artists to create visual art projects extracting elements from the real world. By using the brush artists are able to capture color, texture, and moving patterns using a very simple interaction technique and interface. To capture or collect visual information, users press a button on the brush that triggers a small camera. The captured elements can now be used on a digital canvas to paint with them. The I/O Brush was also the closest to our beliefs in terms of supporting the work of designers with AR by providing a simple interaction and interface.

Probing interviews (20 min.)

After the presentation, we engaged with our participants in probing interviews [Mattelmäki 2005], which lasted twenty minutes. In these interviews, we discussed specific aspects of their probe materials and then checked the interpretation of the main findings from the probes study, looking for further design opportunities. Together with the participants, we went through their respective pictures and transcripts. We were both trying to clarify any doubts left on what they had shared with us, and trying to further discuss ideas we had identified as potentially interesting. Later on, we discussed our general findings from the probes study, namely, 1) supporting flexibility in creation, 2) finding inspiration, and 3) mood boarding.

Experiencing an AR system (60 min.)

In the following hour, we invited participants to have a first-hand experience with an AR system: the Electronic Paper [Aliakseyeu *et al.* 2006] (Figure 9, top-left). This prototype was originally targeted at the early stages of architectural design, integrating traditional pen and paper with computer functionalities (such as for creating, handling, storing and retrieving images and sketches), making it suffi-

Figure 11. The Electronic Paper prototype

Hardware (left) – An LCD projector beam, infrared light source, and camera pointed towards the horizontal workspace via a mirror

Graphical user interface (right) – An image browser contains images that can be dragged onto the work surface. A function menu is used to access options for the pen and the images

ciently general to also be of interest to industrial designers. In terms of hardware, it consists of large horizontal surface (A2 Wacom® tablet) on which visual information is beamed from an LCD projector. An infrared light source and black and white camera are used to track physical cards that are coated with reflective material (Figure 9, bottom-right). These reflective cards can be used to select and position virtual objects on the horizontal workspace. The LCD projector beam, infrared light source, and camera are pointed towards the horizontal workspace via a mirror (Figure 11, left). A second vertical display can be accessed via a mouse and keyboard to for example browse the Internet and add elements onto the horizontal workspace (Figure 9, bottom-left). From a software perspective, the system consists of a browser containing images that can be displayed and modified in the horizontal workspace (Figure 9, top-right). The tablet's digital pen and the reflective cards can be used to work with the images and create sketches. A function menu controls several functions such as pen color, thickness and transparency, and to cut and paste images to and from the clipboard (Figure 11, right).

First, one of the researchers gave the participants an interactive tutorial, going together through the different functions of the prototype. In the probes study, the creation of MBs had been identified as a relevant task for designers. We wanted to look further into how industrial designers would create MBs on an AR system. Therefore, we asked them to create a MB for a current or recently finished project. As an alternative, we suggested making a MB for a future project if they had one in mind. The latter suggestion proved to be the most effective as participants were able to quickly think of future ideas that they could define by means of a MB.

Brainstorming session (20 min.)

In the last twenty minutes of the workshop we had a short brainstorming session with our participants, summarizing the different topics covered during the work-shop (i.e. AR, cultural probes, the electronic paper prototype, and MBs).

We started off by asking them about their experiences while creating a MB using the AR system. We wanted to have a conversation on possible uses for a similar technology for their work instead of seeking for improvements to the already existing prototype. We ultimately wanted to steer the conversation in the direction of coming up with other ways of using AR to support their work. In that sense, the videos and prototypes shown during the workshop served as a warm-up activity and opened the participants' mind. We wanted participants to hopefully come up with novel applications of these technologies to support design practice.

2.4.5 Findings

Probing interviews

The results from the probing interviews confirmed our previous findings related to the early stages of the design process (i.e. supporting flexibility in creation, finding inspiration, and mood boarding). Some comments mentioned by workshop participants during the probing interviews have already been included to support some of our findings of the probes study (section 2.3.8).

Augmenting MBs

Regarding our main research question for this second study, designers confirmed to us that, of all the activities identified in the probes study, the creation of MBs was the best candidate to provide support for with AR. By experiencing the Electronic Paper prototype designers were able to see the potential of augmenting MBs.

Designers reflected on some of the advantages of mixing aspects from traditional and digital MBs by bringing the best of both worlds. Bringing MBs closer to the digital world would allow making them in a faster and cheaper way. Designers could easily change the final appearance of the MB, adding and removing materials without having to compromise for a final layout as gluing would no longer be necessary. As a result, MBs would no longer feel so final. As SK pointed out, *"Making digital and AR MBs would be faster than making them in paper because then I have to think carefully about what I want to do because if I make a mistake, I cannot go back."* This comment also brings us to another advantage of moving towards the digital world, which is having the possibility to easily undo your actions.

An AR tool could also support working with images. For instance, a tool could allow importing both images from physical magazines (scanning) and from the Internet in a fast and simple way. Participant MK said, *"with a quick scan, where you*

can take something you like from a catalogue and add it to the system, like the I/O brush." Participant EB expressed his frustration with the way the current Electronic Paper prototype supports importing images from the Internet which should be achieved in a faster and more intuitive way: *"I would like to drag an image with my finger from the vertical screen into the horizontal system instead of doing copy on one screen, paste on another screen, and using a mouse. 'I want that image, here.'"* Breaking the divide between physical and digital collections and images is something that Cabinet [Keller 2005] has already successfully achieved. Besides scanning, designers thought the possibility of easily scaling images up and down (also in proportion) as a potential advantage.

A tool could also allow designers to move and rotate pictures by providing direct manipulation of images with their hands, instead of requiring the use of a keyboard and mouse. The Electronic Paper prototype supports such a manipulation of images by using physical cards on which virtual images are projected. Designers can freely move the images by handling these cards, thus creating an interaction environment where the action and perception space match. Where you act is where you see. MK reflected: *"I see the potential, I like very much the idea of interaction in the same place that I am seeing. I would prefer making a MB on this system because I can work (manipulate images) directly on it."* AO pointed out *"I like the idea of moving images with your hands."* EB added *"this system is better than making it on a computer with a mouse and keyboard. It is an improvement."* Finally SM mentioned, *"You have a one-to-one feeling of what the result will be. It's like an artist (painter), you can view the result."* Designers also mentioned having some quick and expressive way of cropping images or cutting them in a given shape to remove its background as an important feature for AR MBs.

Finally, designers also mentioned as an advantage adding audio and video to better convey moods and feelings. Participant EB told us *"Audio would be great because audio will enhance the feeling you are trying to convey. I see it as adding loops, no editing."*

Rough and sketchy

With a large amount of features, current computer programs offer the type of precision that is better suited for the later stages of the design process. In order to use these programs, designers must be very precise in their actions. On the other hand, the creation of MBs is not such a detailed activity and therefore a rough and sketchy way of creating them should be provided. Interactions that require designers to be very precise and aware of their actions would take away the kind of intuitiveness needed to support the designer's creative impulses.

Designers liked the fact that the Electronic Paper prototype provides a rough and sketchy mode to make MBs. However, the optical tracking when manipulating images would sometimes be too sensitive, forcing designers to be very precise and aware of what they were doing. This type of interaction resulted in losing some of the

Figure 12. Don't kill the illusion

Keyboard and mouse – After experiencing the naturalness of handling images using the reflective cards, partici-

pants reported bringing a keyboard and mouse breaks the illusion of the experience

freedom and sketchiness required to make MBs. SK tried to put it in other words by saying *"when I have scissors, I want to be able to make a detailed cut which requires more attention because I want it that way and not because the scissor is asking me to be always careful."*

Don't kill the illusion

Designers also asked us not to kill the illusion, meaning that it is very natural for them to become involved in the experience of manipulating digital images. However, whenever external physical interaction elements such as a keyboard or a mouse are brought into the interaction environment (as is the case on the Electronic Paper prototype), the illusion is broken (Figure 12). Participant EB said, *"Sometimes I am taken away from the system. The mouse and keyboard take me away from the world. I would like to be in one tool (now it feels like two separate ones)."* Participant AVS added, *"It is irritating to switch between the tablet, the keyboard and the mouse. That is why I don't use tablets: you either do everything with tablets or else, not."* SK told us, *"To use the button on the digital pen is not intuitive as it makes me stop and think. I have to remember how to do it."* The interruption or distraction made by these external elements diverts attention and thus works as a major inhibitor to the immersive experience.

An undo function, which is typical of the digital world, could also potentially break the illusion. In situations where direct manipulation of elements is supported, having an undo function that results in moving an image that is being currently manipulated by the designer could create an unexpected or unwanted effect. Undo is already supported with physical interaction by the fact that you can physically take the image back to the previous position.

Working with two hands

Designers prefer working with their hands. There are three main aspects behind this concept of working with two hands: both hands collaborating simultaneously, both hands directly interacting with digital elements, and tactile feedback to 'feel' the digital elements.

Designers said the concept of being able to use both hands to interact with the system was very interesting and should be encouraged. Participant SK said *"I like shifting and turning (images) with my non-dominant hand, where both hands help each other. I liked that one hand was doing different things, like with a knife and fork."* Participant EB added, *"Using the card in the left hand while holding the pen with your right hand is nice so you work with two hands simultaneously"* (Figure 13, left). On the current Electronic Paper prototype, working with two hands in collaboration is possible but designers tend to do one thing at a time, namely, sketching and arranging images as separate sequential actions.

Second, designers elaborated on the two-handed interaction concept by requesting direct interaction with their hands. Designers said they prefer not having intermediaries in the interaction so whenever working with their bare hands is possible it should be supported. For example in the current system, designers thought the pen was an unnecessary intermediary to allow them to move and rotate images. ER said, *"Why can't I just click and draw with my fingers? It could work very nicely."* EB told us *"I want to be able to move pictures with my hands and not with a tool (card or pen). Maybe gesture interaction could solve that."* Whenever working with their bare hands is not possible small, simple, and easy-to-handle elements such as the current cards should be encouraged.

Third, designers liked the feeling of grabbing, this is, the feeling of manipulating digital pictures and having the tactile feeling of taking them (Figure 13, right). Participant EB said, *"I have more grip with what I am doing because I am doing things in the real world. It is more realistic than on computers because I feel I have something under my hands and not a virtual thing that is on a screen."* The reflective cards gave designers the feeling of touching paper with their hands, as it was an actual card made of paper. FV added, *"I liked the feeling of grabbing, that you are making use of the full space (tablet), that your body is connected to moving and rotating objects."* Providing this kind of tactile feeling is an important factor for creating the sensation of grabbing for designers.

Keep it simple

The first intuitive reaction from designers when asked about how to improve the current support given by the Electronic Paper prototype to the creation of MBs is to start listing several functions and filters currently found on commercial graphic software such as Photoshop® or Illustrator®. However, after giving it a second thought, they all realized that the power of a tool that supports the creation of MBs
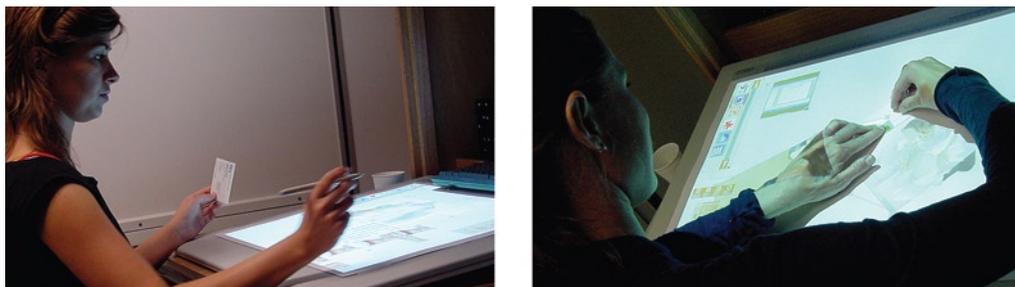
Figure 13. Working with two hands

Hands in collaboration (left) – Holding the digital pen and reflective cards in different hands to perform tasks simultaneously

Feeling of grabbing (right) – Having a tactile feeling when manipulating digital images using reflective cards

is based on being sketchy and rough. As MK put it, *"the power is in the simplicity. The simpler you make it, the better."* Therefore, the final message from designers when designing an AR tool that supports the creation of MBs is: keep it simple.

2.4.6 Conclusions

Augmenting MBs
During the workshops, we were able to further discuss our findings from the probes study with our participants. Designers also had the chance to experience an AR tool, which they used to create a MB. As a general remark, designers saw the potential of supporting the creation of MBs with AR and encouraged us to do so.

Rough and sketchy
As the creation of MBs is not such a detailed activity, designers prefer having a rough and sketchy way of making them. Interactions that require designers to be very precise and aware of their actions would take away the kind of intuitiveness needed to support the designer's creative impulses and thus should be avoided.

Don't kill the illusion
Designers also asked us not to kill the illusion. When designing and AR tool, special care should be taken in avoiding bringing into the environment physical (or digital) elements that could break the illusion of the experience. For example, bringing in the physical keyboard or mouse were both reported as illusion breakers. Simple and realistic alternatives to address this issue might include the use of a digital keyboard instead of a physical one, deleting images by dragging them to a 'delete zone' on one side of the work surface instead of clicking an 'x' button, or using virtual layers on top of the table instead of having tabs for different pages.

Working with two hands

In the early stages of the design process for activities that involve creation, designers prefer working with their hands. First, being able to work simultaneously and in collaboration with both hands is something designers would like to be able to do. As one designer put it, it is like the metaphor of a using a knife and fork: one holds the food in place while the other cuts. Second, designers prefer not having intermediaries in the interaction so whenever working with their bare hands is possible it should be supported. Third, designers liked the feeling of grabbing, this is, the feeling of manipulating digital pictures and having the tactile feeling of taking them. The reflective card created the feeling of taking paper in their hands because it was an actual card made of paper. Providing this kind of tactile feeling is an important factor for creating the sensation of grabbing for designers.

Keep it simple

Designers said to us that the power of a tool that supports the creation of MBs is based on being sketchy and rough. Therefore, designers advised us to keep the interaction simple. The power will be in its simplicity.

2.5 Student project

2.5.1 Problem

After identifying mood boarding as an important task for industrial designers that could be supported with AR, there were several aspects that we wanted to explore further. For example, we had not yet been able to observe how designers make MBs. We also needed to really understand what are some of the difficulties and possible opportunities of moving this task to AR. Designers make traditional MBs using physical magazines and mounting boards and digital MBs on their computers with images they download from the Internet. Therefore, we needed to identify what are the main advantages that AR could bring to mood boarding with regards to efficiency, effectiveness or joy of use in comparison with the traditional or digital ways of making MBs. Although our participants were industrial design students and not professional MB makers, we nevertheless thought they would provide us with valuable input on how MBs could be made under these three different conditions (i.e. traditional, digital and in AR). This third study would be our last step in trying to define a focus for this research before doing more intensive contextual studies with practicing designers who make MBs. The main research question for this third study was *what are the main difficulties and opportunities of moving mood boarding to AR when compared to the traditional and digital ways of making them?*

2.5.2 Approach

During an eight-week project with industrial design students we observed the cre-

ation of MBs in the context of a real project. The students' task was to consider how the creation of MBs could be better supported by AR systems. In order to achieve this, they went through different phases. In the first four weeks, they got acquainted with the task they were supporting (i.e. mood boarding). First, they individually explored how traditional MBs are made. Second, they created their own digital MBs on their laptops. Third, they created a MB on an AR system using the Electronic Paper prototype [Aliakseyeu *et al.* 2006]. In this way, we were hoping that students would have a first-hand experience of the advantages and disadvantages of creating MBs with AR systems. In the final phase, students designed a new interaction concept for creating MBs in AR from the knowledge and experience gained during the first four weeks of the project. They worked in 6 groups, identifying uncovered needs and translating them into a new interaction concept proposal. Each group received guidance from a coach that was assigned to them. The coaches were either practicing industrial designers or worked in design research and spent one day per week in design education. Additionally, Jean-Bernard Martens had the role of being the students' client.

2.5.3 Participants

Thirty-two first-year students from the Department of Industrial Design at the Eindhoven University of Technology (TU/e) took part in the project. The project was the second of two eight-week projects that students complete during their first semester. As such, all students had previously completed at least one large project as well as several shorter individual assignments that students take according to their interests. The students had no previous experience with mood boarding or AR. Education is mainly given in English with only a few assignments given in Dutch. The students' communication skills in English were good. As such, the language used throughout the project was English.

2.5.4 Procedure

The project was conducted over a period of eight weeks between November 10 and December 23, 2005. The project consisted of five main parts: 1) kick-off meeting and workshop, 2) making traditional, digital and AR MBs (weeks 1-4), 3) interim presentation, 4) developing a concept (weeks 5-8), and 5) the final presentation.

Kick-off meeting and workshop

The project began with a kick-off meeting where students were introduced to the main topics of the project by means of two one-hour lectures given by the author. The main topic covered in the first lecture was the creation of MBs and included an overview of how designers find inspiration, keep scrapbooks and folders with images, and use these materials to create MBs [Dabner 2004]. The second lecture

Figure 14. Stages of the student project "Making MBs in AR"

Traditional MBs (top-left) – Students created physical MBs using magazines and books

Digital MBs (top-right) – Students looking for images from the Internet on their laptops for their digital MBs

MBs in AR (bottom-left) – Students created their own MBs in AR using the Electronic Paper prototype

Interim presentation (bottom-right) – Groups presented the MBs made using the three different techniques

consisted of an introduction to AR and was mainly based on the presentation given to industrial designers during the workshops (see section 2.4.4). At the end of these two lectures, students were given the project brief with an explanation of what was expected from them during the eight-week project. During the kick-off meeting, students were asked to begin gathering visual material (i.e. magazines and books) and other elements that could be used in making their own MBs. Students were asked to bring the collected materials to a workshop later that week.

The workshop itself consisted of making traditional MBs (Figure 14, top-left). Students brought their materials together with scissors, glue and an A1 mounting board. Students spent the entire day creating traditional MBs under the supervision of an expert on MBs who helped them select the material and discuss the concepts and messages they wanted to communicate with their MBs.

Making traditional, digital and AR MBs (weeks 1-4)

The work and deliverables for each week were clearly divided. During the first week, after the MB workshop, students individually explored how to make traditional MBs using images from magazines and gluing them on a mounting board. In week two, students created digital MBs by searching and downloading images from the Internet and later assembling them using a photo-editing program (Figure 14, top-right).

During week three, all thirty-two students spent an hour working on one of the two running Electronic Paper prototypes to create a MB in AR (Figure 14, bottom-left). First, students went through a 15-minute tutorial that covered the main functionalities of the system needed to make a MB.

By the end of the third week, students had each made three MBs: one traditional, one digital and one in AR. We then asked students to fill out a questionnaire ranking the different techniques to make MBs in order of preference.

In week four students worked individually on their new interaction concepts and finally get together as a group to decide which concepts would be presented at the interim presentation.

Interim presentation

At the end of the fourth week each group presented the main findings of their research thus far (Figure 14, bottom-right). Students had been asked to thoroughly document their individual MB making processes. One student per group guided the audience through the different MBs each group member had individually created. As the presenter explained what the main concepts behind the MBs were, comments regarding problems or positive aspects of making MB in a specific way were also included in the explanation. Finally, after all MBs had been presented, they introduced their new ideas for what could potentially become the interaction concept for creating MBs in AR. Students were given feedback on their ideas by all coaches.

Developing a concept (weeks 5-8)

During the final four weeks of the project, students worked in groups to develop one of the concepts presented during the interim presentation. Their new designs could focus on supporting mood boarding by either improving the current desktop interaction as was used on the Electronic Paper prototype or by envisioning other interaction techniques (e.g. full-body interaction, mobility). Whichever approach they took, the final concept was to be presented as a 1:1 scale model. A three-minute video showing the intended interaction was also part of the project deliverables. We challenged students to think of new ways of creating MBs that could include adding audio, video, or movement.

Figure 15. Video prototypes of systems that support the creation of MBs in AR made by students

BlueEye (top) – Collecting and interacting with 2D and 3D objects using hand gestures

MUM (Bottom) – Collecting, sharing, and co-creating MBs using mobile phones

Final presentation

At the end of the project each of the six groups presented their final interaction concepts for making MBs in AR. The proposals covered different aspects of making MBs. Among the more traditional or expected ideas, four projects were focused on navigation and interaction (Moodcube), portability and mobility (@mo), supporting image searches (Twigg' it), and presentation in virtual reality (Mood-In). The video prototypes created by two teams stood out from the rest for their valuable contributions. First, the BlueEye system [Martens *et al.* 2006] (Figure 15, top) has the ability to collect 2D and 3D objects, enrich MBs by adding movements (and sounds), and control the system by means of hand gestures. The system bears resemblance to the Cabinet system [Keller 2006a]. Second, the MUM (Multi-User MB) system (Figure 15, bottom) allows people to collaboratively create MBs using their mobile phones. First, people can collect interesting materials they see while on the go, or request other people to make snapshots for them (e.g. if someone is on the train). People can then meet, share their images and use their mobile phones to manipulate the images in different ways.

2.5.5 Findings

Traditional, digital, or AR

Table 1. Participant rankings for the overall preference of the three techniques (i.e. traditional, digital and AR ways of making MBs).

	Traditional	Digital	AR
■ 1	8	19	5
■ 2	15	6	11
■ 3	9	7	16
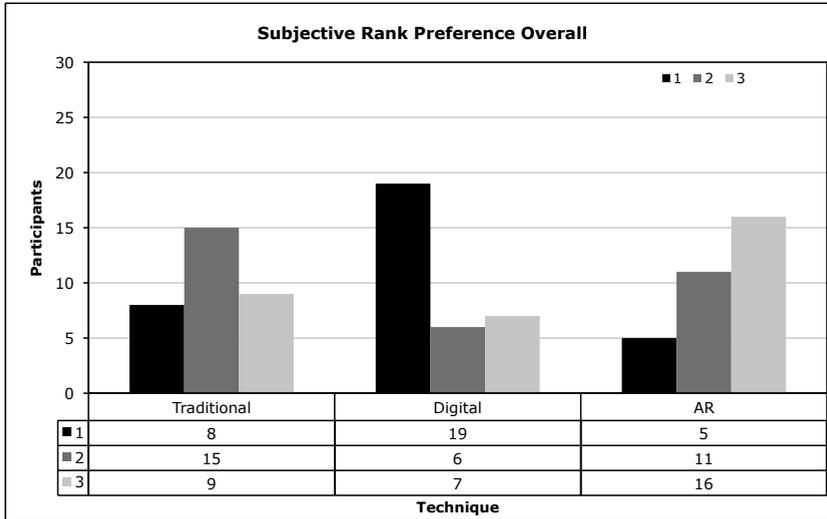
Regarding our research question, we first looked into the data from the questionnaires. Participants ranked each technique on a scale of 1 to 3 (where 1 is best and 3 is worst) based on overall preference, perceived speed, easiness, and fun. Due to the small sample size, a series of Fisher's exact tests was performed for the significance of the difference in preference between techniques.

For the overall preference of the technique (Table 1), we observed that participants significantly preferred the digital way to both the traditional ($p < 0.01$, one-tailed Fisher's exact test) and the AR ($p < 0.01$, one-tailed Fisher's exact test) ways of making MBs. The digital way of making MBs was ranked first by 19 participants, the traditional way by 8, and in AR by 5. Our results show that design students tended to favor the digital way of making MBs over the traditional or AR ways. Why make a mess with papers all over the place and glue things to a mounting board that afterwards can no longer be changed? Participants were in general positive and open to an AR tool that supports the creation of MBs. However, similarly to what workshops participants had told us, this support should be provided in a different form than what the Electronic Paper prototype currently gives.

Table 2. Participant rankings on the perceived speed of the three techniques (i.e. traditional, digital and AR ways of making MBs).

Subjective Rank Preference on Speed

	Traditional	Digital	AR
■ 1	0	8	24
■ 2	6	20	6
■ 3	26	4	2

Technique
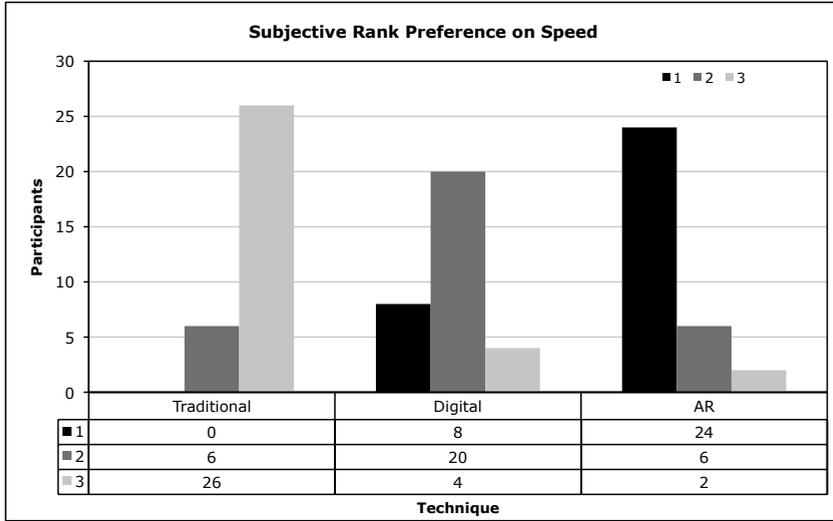
Regarding the speed (Table 2), we observed this time that participants significantly preferred the AR way to both the digital (p < 0.01, one-tailed Fisher's exact test) and the traditional (p < 0.01, one-tailed Fisher's exact test) ways of making MBs. Participants also significantly preferred the digital way to the traditional way of making MBs (p < 0.01, one-tailed Fisher's exact test). Again design students thought the traditional way of making MBs was the most time-consuming. Actually, 26 participants ranked it as the slowest of the techniques. Participants said it is harder to find pictures due to the large number of magazines that they have to browse through. Cutting images with scissors and gluing them on the mounting board were also mentioned as reasons for slowing down the making of traditional MBs. On the other hand, a large number of participants (24) ranked making MBs in AR as the fastest technique. This shows that students did see a potential in making MBs faster even than on their laptops. Some of the reasons given for this include the possibility of working using both hands, the direct manipulation of images to rotate and move, and the large work and display area.

Table 3. Participant rankings on the perceived easiness of the three techniques (i.e. traditional, digital and AR ways of making MBs).

Subjective Rank Preference on Easiness

	Traditional	Digital	AR
■ 1	18	4	10
■ 2	7	8	17
■ 3	7	20	5
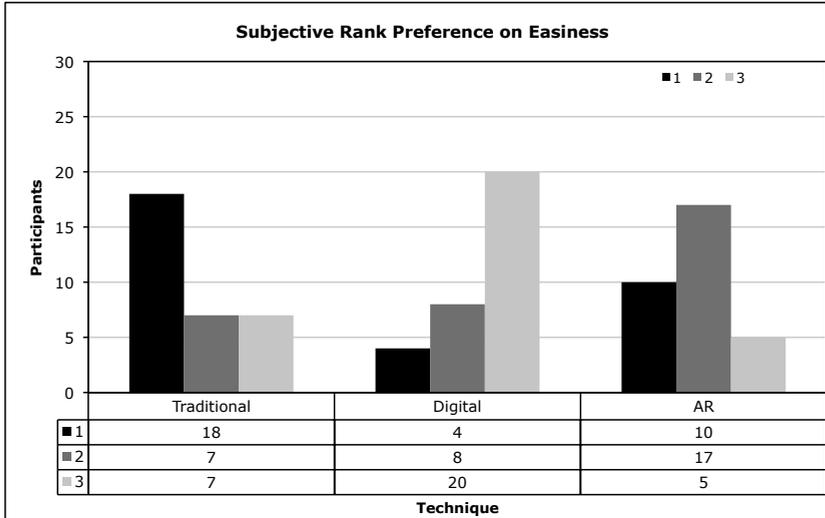
In relation to the easiness of making MBs (Table 3), we observed that participants significantly preferred the traditional way to both the digital ($p < 0.01$, one-tailed Fisher's exact test) and AR ($p < 0.05$, one-tailed Fisher's exact test) ways of making MBs. Participants thought traditional MBs were the easiest to make as more than half of them (18) ranked traditional MBs first. The basic set of skills and actions needed for making MBs are actually mastered by most people already in their infancy. Manipulating, cutting and gluing images are things that most people can easily do without further explanation. Participants said that being able to touch and move pictures around without any other external tools was a big advantage of traditional MBs. They also said traditional MBs become a social activity where it is easy to discuss and share pictures with others (Figure 16, top-left). Finally, participants said that the scale in which MBs are made gives a good overview of the materials and MB contents (Figure 16, top-right). In contrast, we observed that participants significantly rejected (by ranking the technique last) the digital way in comparison to the traditional ($p < 0.01$, one-tailed Fisher's exact test) and AR ($p < 0.01$, one-tailed Fisher's exact test) ways of making MBs. Twenty participants ranked digital MBs last in terms of easiness. It takes a lot of practice to master the tools needed to make a digital MB. Probably cutting out pictures using software is the best example of how a simple task in everyday life can become difficult to achieve using a computer. Participants also argued that the lack of overview due to reduced screen size, and tangible feedback were also reasons for not preferring digital MBs in terms of easiness.

Table 4. Participant rankings on the perceived fun of the three techniques (i.e. traditional, digital and AR ways of making MBs).

Subjective Rank Preference on Fun

■	1	Traditional	Digital	AR
■	1	7	5	20
■	2	10	14	8
■	3	15	13	4
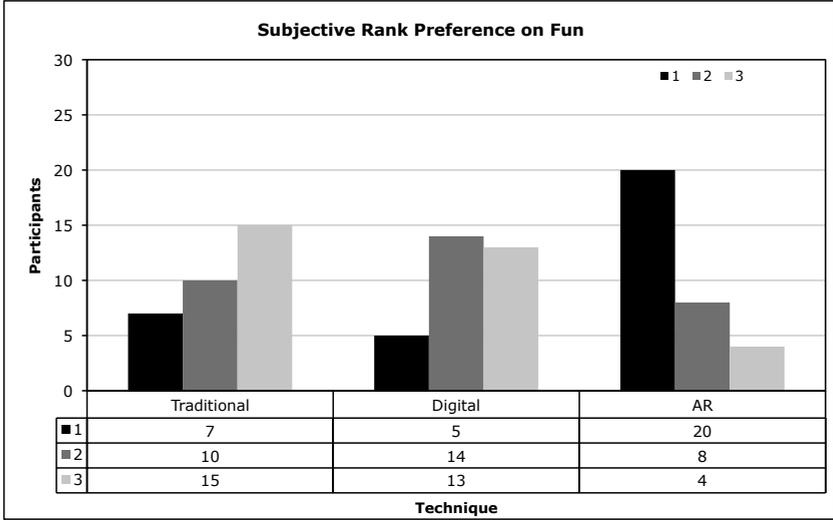
Technique

Finally, regarding how much fun it is to make MBs using the different techniques (Table 4), we observed that participants significantly preferred the AR way to both the traditional ($p < 0.01$, one-tailed Fisher's exact test) and digital ($p < 0.01$, one-tailed Fisher's exact test) ways of making MBs. Participants ranked a similar amount of times traditional and digital MBs in first place (7 and 5 times respectively), and considered MBs in AR to be the most fun by ranking it in first place 20 times. Students especially mentioned the more dynamic aspect of making MBs instead of sitting on a chair watching a monitor as a big advantage in AR. They again mentioned the social aspect of being able to make MBs in collaboration with other people (Figure 16, bottom-left).

Intuitive interaction

Participants pointed out the advantages of having a direct interaction with their hands to move and rotate images. They especially liked the fact that they could walk up to the system and start interacting with the images with no further explanations needed. There were no hidden functions, menus or complex actions that had to be learned. As they were already familiar with the kind of skills needed to use the tool, interacting with the system thus made sense to them. Design students described the system as *"quick to understand how to use it."* This simple and direct way of interacting with a tool, without needing further explanation or getting used to it, is what we should then aim for and what we will call *intuitive interaction*.

Figure 16. Student project findings

Social activity (top-left) – Traditional MBs makes it easier to have discussions and share pictures

Good overview (top-right) – Students laying their MBs on the floor to have extra space and look at them from a distance

MBs in collaboration (bottom-left) – Students working together on the AR system to create their MBs

Keeping a positive attitude (bottom-right) – A group of students explore making MBs collectively while creating a relaxed and fun atmosphere

Creating a positive state

Earlier, students mentioned the dynamic nature and the physical activities required to do a MB as a potential advantage of making them in AR. They also mentioned the social aspect of making MBs with more people around. Regarding the latter, several participants mentioned the positive attitude and relaxed atmosphere created in their workplaces while collectively involved in the physical activity of making a MB using the Electronic Paper prototype (Figure 16, bottom-right). They would discover, discuss, create, and think together around the system. Participants referred to this enriching atmosphere as a defining factor in preferring AR MBs in terms of fun. Keeping a relaxed and good mood creates a positive effect that facilitates creative thinking in designers [Norman, 2004]. As such, support tools should aim at creating this feeling of being relaxed and in a good mood. Helping designers achieve this state might increase their productivity or creativity at work.

Adding more functionality

Design students requested more functionality (than what the Electronic Paper prototype currently provides) for a tool that supports the creation of MBs. As students interacted with the system, they showed the same intuitive reaction that practicing designers had in the workshops, requesting several functions. Students saw the system's potential, which triggered a *"more is better"* reaction in them. They requested to *"add more functionality"*, similar detailed and powerful functionality found on commercial software such as Adobe® Photoshop® or Illustrator® (e.g. layers, cropping, scissor-like cutting). After this initial request for more functionality, workshop participants told us to *"keep it simple"* as the creation of MBs is based on being sketchy and rough. In contrast, students did not reach this stage in their reflection and insisted on having *"a larger amount of editing possibilities."*

2.5.6 Conclusions

In the student project, we were able to observe 32 design students making MBs the traditional, digital and AR ways. It also allowed us to understand what are some of the difficulties and possible opportunities of moving this task to AR.

Traditional, digital, or AR

Students identified positive and negative aspects of the different ways to make MBs. Among the positive aspects of making MBs the traditional way, they mentioned the simplicity of physical (tangible) actions needed to create a MB (e.g. handling paper, cutting with scissors), that it is a social activity where people discuss and share pictures with each other, and that the large scale of MBs provides a good overview of materials and contents. Among the negative aspects, they said it was a time-consuming task as it is harder to find the right pictures with all the magazines they have to browse through, that cutting out pictures from magazines creates mess in the design studio, and that once materials have been glued to the board, it becomes permanent.

Regarding digital MBs, some positive aspects included having many editing possibilities (e.g. undo, change color, crop), there is a large choice of pictures, and no mess is created in the design studio. About the negative aspects, students mentioned it is hard to learn and master, lack of overview due to reduced screen size, and there is no tangible feedback.

Finally, about MBs in AR, students mentioned being able to work with both hands simultaneously to directly manipulate images (i.e. rotate and move), having a large work/display area, and the possibility of having more than one person working on the MB as positive aspects. On the other hand, students mentioned the limited number of functions, the lack of layers, and the clumsy response of the interaction elements (i.e. the reflective card and digital pen) as negative aspects.

Intuitive interaction

Participants liked the fact that they could simply walk up to the tool and start interacting directly with it using their current skills and knowledge on the task that is being supported. There was no need for further explanations or getting used to the tool. There were no hidden functions, menus or complex actions that had to be learned. This simple and direct way of interacting with the tool is what we refer to as *intuitive interaction*.

Creating a positive state

Participants mentioned a positive attitude and relaxed atmosphere that was created in their workplaces while collectively involved in the physical activity of making a MB in AR. Keeping a relaxed and good mood was possible partly due to the nature of the task as well as to the dynamic, social, simple, and stimulating interaction and context of creation.

Adding more functionality

Design students requested *"a larger amount of editing possibilities."* Some of the functions requested by them such as the inclusion of layers might prove useful for the support tools we would like to provide. However, we must look at the bigger picture and remember that in the second study practicing designers had told us to *"keep it simple."* We believe students are less familiar with the nature of mood boarding and thus it is more difficult for them to go to an abstract level and think about the implications and the needs for supporting this task.

2.6   Discussion

2.6.1 Probes to study professional work

From our probes study we learnt that applying this method in professional environments has special characteristics that must be addressed. For example, introducing probes in the work place can have a negative effect due to interruptions to the work of the participants. Answering questions on a diary can be a significant distraction from the participant's main task. Participants are often reluctant to take part in these studies [Carter & Mankoff 2005].

Based on these concerns we proposed a set of considerations for designing professional probes [Lucero & Mattelmäki 2007a], that is, probing materials to be used to broaden the designer and researcher's understanding of the topic that is being studied. From our findings we propose five considerations for applying professional probes that address the main challenges researchers and designers will face when designing professional probes:

× *Professional probes should aim at low time-consuming activities that reduce the demands on the participants. Photo and audio capturing should be considered as alternatives to diaries.*

× *Professional probes should encourage a fluent and playful process for participants while documenting their work. The materials should be easily approachable per-haps even have a funny character to be perceived by participants as a pleasurable extra for their work.*

× *Professional probes should be tuned in to the special nature of the work that is be-ing studied. Discussing the probe contents before deployment with management or potential participants will allow the probes to successfully enter the environment they were sent to study.*

× *Professional probes should be flexible enough to encourage the use of different strategies, allowing participants to work in ways that are meaningful to them.*

× *Professional probes should aim at motivating participants by providing inspiring, unique, handmade probe materials that are made especially for the study that is being undertaken. Materials should be tailored to create empathy both for the participants and designers.*

2.6.2 Practicing designers vs. design students

In the first two studies (i.e. probes and workshops) our participants consisted of practicing designers. In the third study on the other hand we invited first-year in-dustrial design students to participate. Besides the evident difference in experience with regards to design skills and practice, we also observed a change in education. There is a big difference in the education received by design students today versus twenty years ago. Today students are familiar with digital tools and thus depend heavily on them. Their sketching and hand modeling skills are deteriorating and have been partly (if not completely) replaced by powerful 3D modeling tools. For example our participants, industrial design students from the Eindhoven Univer-sity of Technology, all get laptops in their first year at university. It therefore comes as no surprise that they would so overwhelmingly put in first place the digital way of making MBs (19) over the traditional (8) or AR ways (5). What we observed in the probes study was the exact opposite trend where experienced designers wished to go back to the old practice where they could shape their ideas away from comput-ers using pencils and paper to sketch.

Students also asked us to *"add more functionality"* to the AR tool. They were unable to go beyond the wow effect or the phenomenon of student obsession over new technology instead of artistic substance [Eber *et al*. 2002]. We believe that our first-year students were less familiar with the nature of mood boarding and the old practice thus it became more difficult for them to go to an abstract level and think about what are the implications of supporting the creation of MBs. Although some

of the functions requested by students might prove useful for the support tools we would like to provide, especially the use of layers, we must look at the bigger picture and understand what practicing designers have requested in terms of keeping the tool simple.

2.7   Conclusions

To provide practicing designers with a sensible AR support tool for their work, I had to first study and understand design practice. How do designers currently work? What are their needs? What tools do they use? I systematically conducted three studies to find answers to these questions. First, in the probes study I identified a set of important ideas or possible directions for supporting the work of industrial designers with AR. Most of these findings were connected to supporting creativity and finding inspiration in the early stages of the design process. Along the lines of these findings, I also identified the creation of MBs as a relevant task for designers that could potentially become the focus of my research.

Second, by collectively discussing the probes results with the participants in workshops, I confirmed that the creation of MBs was the best potential activity to support with AR. The purpose of the workshops was also to confront designers with an AR tool. Participants also gave me key aspects to consider when supporting the creation of MBs with AR. They mentioned the rough and sketchy nature of MB making, and the power of being able to use both hands in activities that involve creation. They also requested allowing designers to remain captivated by the experience of the interaction, and to pay attention so that external elements do not break the illusion of the experience. Finally, they also advised us to keep the interaction simple.

Third, in the student project, I was able to observe how MBs were made using different techniques such as the traditional, digital and AR ways of making MBs. Students also saw the potential in augmenting MBs. By directly comparing the different techniques students gave their insights on providing an *intuitive interaction* that allows designers to simply walk up to the tool and start performing tasks without needing to read manuals or learn new skills to master it. They also liked the positive and relaxed mood created by the dynamic, social, simple, and stimulating interaction and context of creation.

In summary, at the end of these three studies I have enough insights and understanding on design practice, especially with regards to the early stages of the design process. I also have identified a relevant task for designers, the creation of MBs, and both practicing designers and design students have confirmed and encouraged me to provide support for it with AR. The next step would be to really study in detail and understand what the creation of MBs was all about, trying to find its essence.

MOOD BOARDS

3 Mood Boards

3.1 Problem

The three studies described in the previous chapter allowed me to obtain a better understanding of design practice in general and to find a specific task that would be the focus for my future research. After identifying the creation of MBs as a concrete activity that could be supported by AR, I realized I knew very little about the task that I was about to provide support for. I had to go in depth and try to understand what the essence of MBs is. To achieve this, I would have to talk to several MB designers or MB makers, discuss their MBs, and hopefully observe them while actually making a MB.

I had already talked to several practicing designers and design students about design and MBs but I had spent very little time in design studios observing designers at work. Up to this point I had only been in design studios when delivering and collecting the probe kits. The rest of the studies had been conducted in the safety of our research labs (i.e. workshops) or classrooms (i.e. student project). So my next task would be to go into the design studios, spend a great deal of time there and learn about MB making in situ.

3.2 Related work

MBs (Figure 17) are common practice in design processes. MBs play an important role in design communication in different design disciplines such as in the knitwear and fashion industries [Eckert & Stacey 2000], in graphic [Dabner 2004] and industrial design [Muller 2001], in interaction design [Øritsland & Buur 2003], and in television and theater [Cristiano 2007].

MBs provide a mechanism for students and practicing designers to respond to perceptions about the design brief [Garner & McDonagh-Philp 2001]. According to McDonagh and Denton [2005], MBs have two main functions: one of *inspiration* for a designer or design team, and another of *communication*, supporting both internal and external dialogue with other stakeholders. MBs consist of a collection of mostly abstract media (e.g. images, textures, forms, colors, and so on) [McDonagh & Storer 2005] to visually encapsulate qualities of mood, atmosphere and voice [Dabner 2004]. Some images are included purely for their visual properties, others for their cultural properties [Eckert & Stacey 2000]. MBs allow designers and clients to approach a given design problem from different perspectives, thus serving as an aid to *lateral thinking* [de Bono 1970].

The current literature provides several tips for making MBs. First, MBs should not be expensive or time consuming to construct [Garner & McDonagh 2001]. Just as for sketches, this does not mean that they have no value, but that cost or time must not inhibit the ability to explore ideas, especially early in the design process
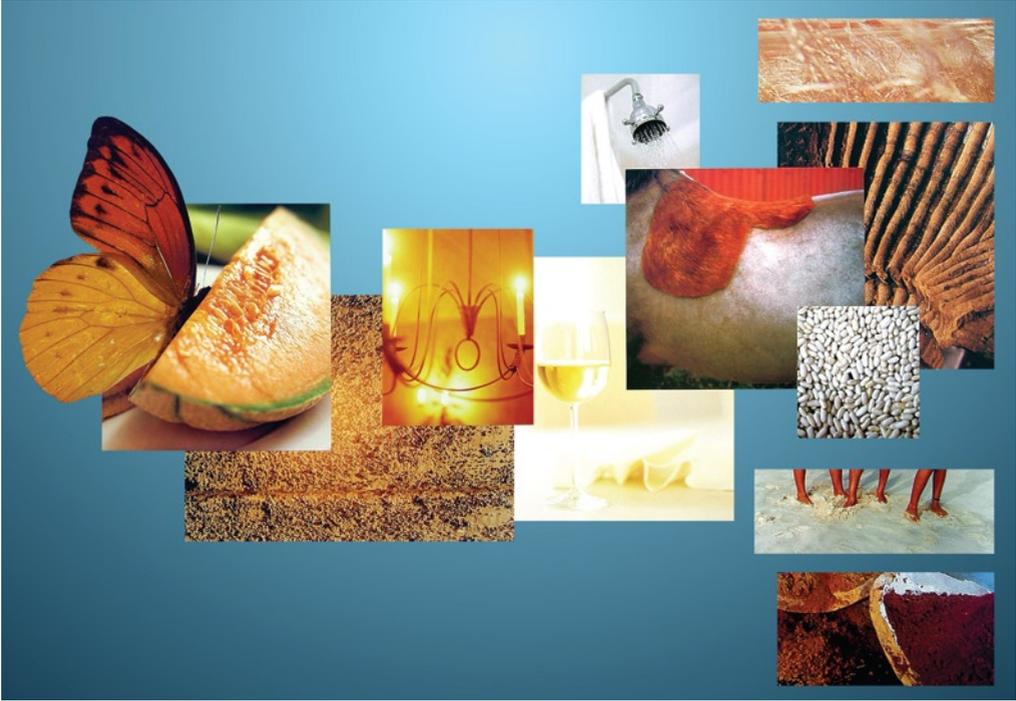
Figure 17. Mood board example: 'Senses' MB put together by the author

This MB is an exploration for an AR tool that supports MB making using more senses than just sight. These images were included for their visual or cultural properties. Several interpretations can be made from these images beyond their literal meaning. A verbal explanation accompanies this MB. The value of MBs as an idea development tool lies in the discussion and subsequent reinterpretations from the images and text

[Buxton 2007]. Depending on the type of project, MBs may be assembled in less than an hour or it may take the designer a couple of weeks to slowly gather the material together, while involved in other activities [Dabner 2004]. Second, as MBs mostly consist of images collected from magazines, books and newspapers, abstract imagery should be preferred to create feelings and moods [Garner & McDonagh 2001], hopefully from sources that are different from the intended design (e.g. waves lapping on a sandy beach to define a color scheme for knitwear) [Eckert & Stacey 2000]. Working with abstraction can support ambiguity in design [Gaver *et al.* 2003]. Third, the items should be selected mostly on a visual basis while having some values or concepts in mind [Bonnici & Proud 1998]. Finally, the images are juxtaposed and glued on an A3, A2, or A1 sheet of card or foam board, making it easy for transportation [Dabner 2004].

Although MBs have been used by designers and taught in design schools for a long time [McDonagh & Denton 2005], the existing literature on this activity is rather limited. In particular, there are very few studies on how MBs are made and used in design practice. There is one notable exception; Eckert and Stacey [2000] analyzed the use of MBs (among other design techniques) to study the role sources of inspiration play in the knitwear industry.

3.3 Approach

In an attempt to find the essence of MBs we have continued our UCD process by conducting contextual inquiries [Holtzblatt *et al.* 2004] with Dutch industrial designers, and MB interviews with Finnish fashion and textile designers. *Empathic design* [Koskinen *et al.* 2003] inspired these interviews in the sense that we built an interpretation of the data to understand the user.

Studying these two groups of designers who use MBs for their work would allow us to compare our findings on different levels. First, we would be able to know how designers from different design disciplines (i.e. industrial, fashion, and textile) use MBs for their work. Second, it would allow us to compare for differences in purpose of use, looking first at Dutch designers who make MBs and leave the rest of the design process in the hands of other design professionals, and later comparing them to Finnish designers who mostly use MBs as part of their own design process. Third, it allowed us to look into how MBs are used in different countries. Finally, having two contexts for our studies would allow us to compare our initial Dutch findings with Finnish designers to confirm and hopefully expand our findings.

3.4 Dutch contextual inquiries

From our previous studies of design practice, we found out that mood boarding is an important task for designers, which is part of a longer chain of events and interactions between different stakeholders (stylists, designers and clients). In order to assess the long-term impact of our research in the work process of industrial designers, we had to observe how they create MBs in their real environment. Therefore, the main research question for this first study with Dutch designers was *what is the essence of making MBs?*

3.4.1 Method

For this study, the method used was contextual inquiries [Holtzblatt *et al.* 2004]. In contextual inquiries participants take the role of experts as they guide the researcher through different aspects of their work. This method allows for a more informal discussion when compared to a traditional interview. There are no pre-defined sets of questions that the researcher must ask. Instead, the researcher will take the role of the apprentice, usually interfering to create a shared understanding of what is going on and to steer the conversation along areas of concern.

Figure 18. Dutch participants in contextual inquiries

LM (top-left) – Stylist/Photographer

MP (top-right) – Industrial designer, graduated from TU Delft

FS (bottom-left) – Designer/Mechanical Engineer, graduated from the Design Academy in Eindhoven

CVDB (bottom-right) – Designer, graduated from the Design Academy in Eindhoven

3.4.2 Participants

Four participants (Figure 18) were contacted based on their experience with making and using MBs in their work. Three of the participants also worked in design research and design education. All participants had at least 10 years of experience in practice (14 years of experience on average). These participants varied in education (university, academy), background (industrial designer, contextual designer, stylist/photographer, designer/mechanical engineer), age (between 35 and 45), and gender (3 female and 1 male). They were owners of their own small companies or were doing freelance work at home. Three of them focused on image/branding while the other participant focused on product design and marketing.

3.4.3 Procedure

Four contextual inquiries were conducted between March 15 and July 7, 2006. The sessions were planned for a total of two hours. In the first 15 minutes, the interviewer (the author) explained the purpose of the session, including the focus of the project, the previous user studies that were conducted, and how the cur-

rent sessions fit within the larger picture of this research. These first 15 minutes also allowed the interviewer to explain the confidentiality policy and how the data gathered would be used.

The actual contextual interview started after the 15-minute introduction and lasted between 60 and 90 minutes. Participants were observed in their workplace while performing the task of making a MB. Participants walked the interviewer through some of their current or previous projects for which they had used MBs. Only one participant was actively involved in a MB making project at the time of the session. Participants usually described between two and five of their projects.

Usually participants spent the first 30 minutes freely presenting their MBs, explaining what the purpose of a given MB was, what the client wanted, the process of making the MB. At the end of this part, the interviewer would go back to one of the MBs and ask a general question about it in order to trigger the participant to go in depth about certain topics.

All sessions were recorded on video. Pictures were also made during the session to capture specific aspects of the work that the participants were describing. Some participants also encouraged the interviewer to make pictures before jumping to a new topic in the discussion.

3.4.4 Interpretation

Interpretation sessions were conducted within 48 hours after the field interviews. The interpretation team consisted of the author plus an independent researcher (Selene Mota). Both interpretation team members made notes using Post-it® notes while watching the corresponding video from the session. Each member created between 80 and 150 affinity notes per participant. The number of affinity notes varied depending on the duration of the interview. Transcripts for all affinity notes were made. Each note was first color-coded to identify the participant (using a different Post-it® color), and then number-coded to identify the affinity note, and which researcher made the note.

3.4.5 Analysis

We assigned meaning to the data collected through interpretation. The analysis team consisting of the same researchers involved in the interpretation sessions walked through the notes in several interpretation rounds. The Post-it® notes from the first three sessions were used to conduct the analysis in several rounds of interpretation. The main purpose of these sessions was to build a common understanding by making a work-modeling diagram and an affinity diagram.

Figure 19. Analysis of the Dutch contextual inquiries

Work-modeling diagram (top-left) – Building tables to create a work-modeling diagram

Affinity Diagram (top-right) – Reading notes to build the affinity diagram

Categories (bottom-left) – Creating an overview of categories emerging from the affinity diagram

Checking the interpretation (bottom-right) – We invited a participant to check the interpretation

The first part of the analysis consisted of creating a work-modeling diagram (Figure 19, top-left). The goal was to identify the different steps in the process of making MBs, including the people, the physical spaces, artifacts, and activities. The final goal was to create a diagram with the different strategies used by designers when making MBs. The researchers read the notes and created a common table for each participant, individually linking the contents of the notes to each of the previously mentioned areas of interest (i.e. people, spaces, artifacts and activities). The table was jointly discussed, spotting the differences between team members in the interpretation, and later resulting into more general findings. A unified version of a work-modeling diagram representing the process of making MBs was created. Once the analysis team felt the diagram was mature enough, the affinity notes were scrambled to create the affinity diagram.

In the second part of the analysis we conducted seven rounds of discussions in a period of ten days to build the affinity diagram (Figure 20). Each researcher read the notes individually and slowly began grouping notes, creating clusters, which later led to categories (Figure 19, top-right). A shared understanding on issues regarding the

client, the relation between client and MB maker, the MBs themselves, and aspects of images was built. These issues formed categories that were naturally revealed, and were jointly revisited, discussed, and redefined. In the end these categories were processed into more general findings (Figure 19, bottom-left). Between six and twenty notes were left out per participant, and per researcher. These notes were often connectors or notes that marked transitions in the discussion when participants started describing another project. Other notes were going into details about the context of the project. Once the affinity diagram was completed, we checked the work-modeling diagram once again in relation to the categories that had emerged.

3.4.6 Checking internally

The fourth session was kept aside to check the reliability of the model in relation to the general categories defined thus far. First, an interpretation session similar as for the first three contextual inquiries was conducted. Later interviewer and researcher added their corresponding affinity notes to the affinity diagram. At this point, existing categories could be removed as well as new ones created. In this process, we were able to check the reliability of both the work-modeling diagram and affinity diagram. Although the fourth participant stressed some aspects over others, she did not greatly alter our perception of how MB designers do their work or of the essence of MBs.

3.4.7 Checking with users

We invited participant FS (Figure 19, bottom-right) for a final external check of our interpretation of the data. The interviewer presented the work-modeling diagram and affinity diagram to participant FS. This process allowed us to enrich and find limits to our interpretation. The session lasted two hours. Although our four participants had different views on certain aspects of the essence of MBs, participant FS confirmed most of our findings and helped us clarify some points we had misinterpreted.

3.4.8 Findings

Idea development

A MB is an idea development tool that helps both the client and the MB designer explore the available design space or range of possibilities when the first ideas begin to emerge. In this early stage of the design process, usually clients have some undefined and rough ideas in mind for a future product, trend, or service, and thus will find difficulty in describing them or expressing exactly what they mean. MB designers and clients hold several meetings where the discussion evolves around topics put on the table by the clients who are trying to share their thoughts and express
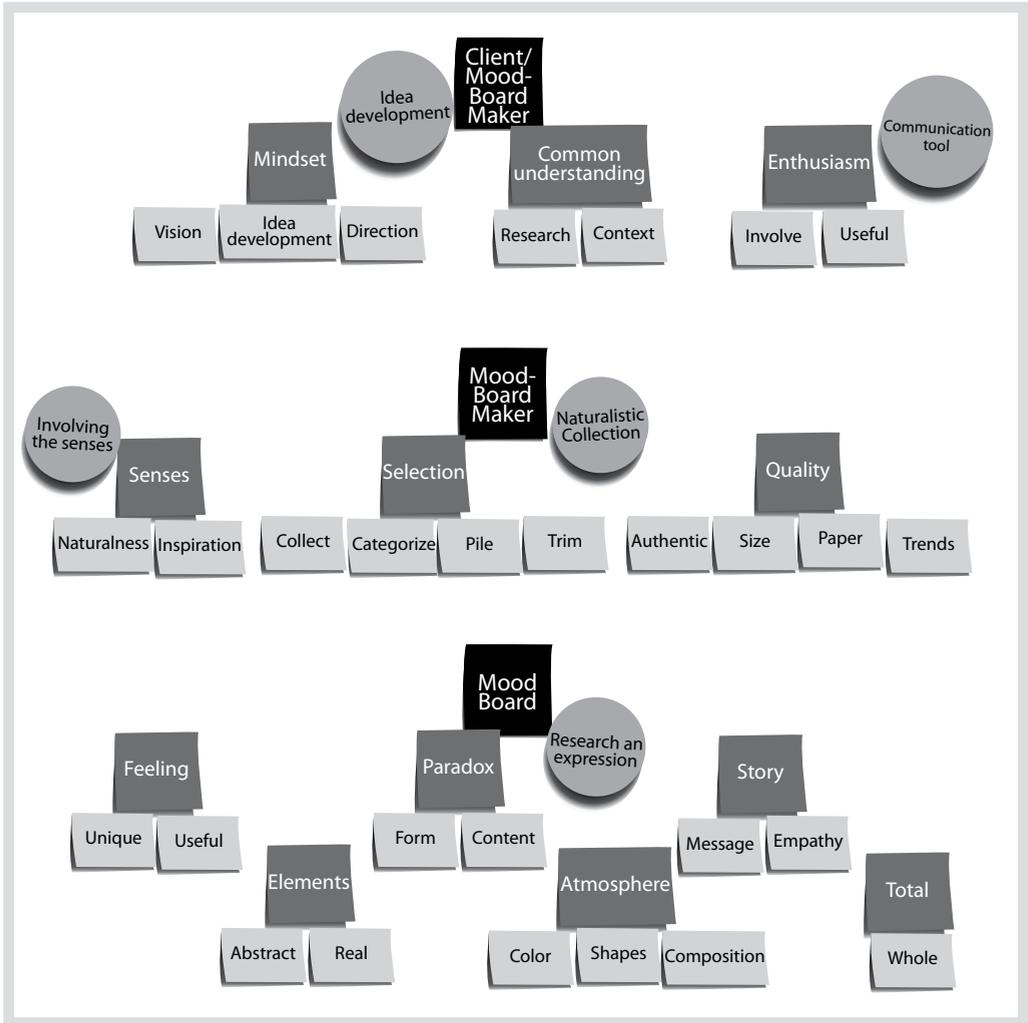
Figure 20. Categories from the affinity diagram

The discussions evolved around issues regarding the relationship between the client and the MB maker, the MB makers themselves, and the MBs shown here as black Post-it® notes. The round notes show the five main findings from this Dutch study

ideas through words. Participant MP reflected: *"we cannot read their mind. Clients transmit their ideas through words. The meaning behind those words is not important; it is the idea they are trying to express which is important. The impressions on the keywords for the designer may be totally different for the client. Therefore, we need to find some level of understanding on what is actually meant."* Through these discussions, the MB designer starts helping the client shape and better define what they have in mind.

The MB designer will interpret the words mentioned by clients and use MBs to visualize the ideas that otherwise clients would have no clue as to what they look like, helping MB designer and client get a better grip of the product, trend, or service they have in mind. In line with this finding, Dabner [2004] indicates that MBs can be a *"springboard for discussion, particularly if a client has problems briefing the designer about a difficult or unclear project that they need resolved."* Regarding the use of words, Eckert and Stacey [2000] indicate that the lack of a universal standard vocabulary for variations of design elements (e.g. human languages have only a small range of accepted color names although a huge number of them are perceptually distinguishable) is prone to misinterpretation.

MBs help clients create and transmit a mindset or vision to different stakeholders. The purpose of creating this new vision may be to change how the company is perceived, or to develop a new product. The iterative process of interpreting, making, and discussing helps the client in defining and transmitting this vision to as many people as possible, so that clients, stakeholders, employees and others are all aligned and share the same perspective. As participant FS told us, *"it is to get everyone on board the same boat, making everybody part of the change."* MB designers help their clients present their vision or general ideas of what they want by asking them questions such as, *"what do you want for the future of your company?," "what is important for you?," "what brand personality do you want this new product to have?"* In a study with design practitioners' views on their use of MBs, McDonagh and Storer [2005] found that *"MB construction can assist in getting all stakeholders on the same wavelength."*

Together, client and the MB designer spend a significant amount of time defining and discussing around topics with their potential target audience in mind. The result of these discussions will be a set of keywords that outline the context of the project, summarizing both the message they want to get across and the target group they want to reach. As such, MB designers need to find out why the clients chose those keywords for this given context before attempting to visualize them for the clients. MB designers must also check how words are determined by a given context or culture. MP mentioned *"for example, 'modern' will mean something completely different to a traditional company than to an avant-garde company. MB makers must interpret terms differently according to the source (company, client, context)."* CVDB added, *"Words are also culturally determined. For Christmas, a fireplace may bring emotional aspects in western culture about coziness but may bring functional aspects about cooking in India. These cultural differences in keywords and colors are crucial in MBs when you are trying to communicate with other cultures."*

Having defined the vision and the set of keywords, MB designers now conduct a thorough research fed by those topics in an attempt to go beyond what the clients are able to verbalize, and to build their own understanding of what the clients told them. In their research, MB designers will look into different elements around the

project that could influence the end-result, reading books and marketing reports, conducting market and competitor analyses, having interviews, and listening to relevant music, to have a strong impression of the issues that should be addressed. MB designers stress the importance of conducting a thorough research from the start as it makes their design period afterwards shorter, or as FS put it, *"it helps speed up the process."* The MB designer processes the information, builds a client profile, and presents it back to the client. The MB designers confront their clients with some of the findings, which help the clients think about their vision once more. Clients might want to project a brand personality that does not suit what their company stands for. Based on the research, MB designers can advise the client on the soundness of their intentions.

The entire process of trying to understand what is in each other's mind by first defining the vision and keywords together, and later presenting and discussing the results of the thorough research, allow both client and MB designer reach an agreement and create a common understanding.

A completed MB sets a new direction for design. The MB will be a result of the ongoing discussions, reflecting the mindset or vision that was discovered and defined together with the client. So in the end the MB will not come as a surprise, it will be the result of these discussions. MBs can serve as a reminder for designers to focus on this new direction, and as inspiration for the future designs. MP mentioned that, *"by comparing the final product and the MB that set the direction for design you should be able to see that they are related; that they are family but not twin brothers. The MB should be a reference."* MBs are used to communicate this direction internally to salesmen, marketing people, product developers, and other stakeholders so they all share the mindset or vision for the future product. This finding is inline with Garner and McDonagh [2001] who indicate that, "in a successful process, MBs seem to indicate the direction of travel for design and development."

Research an expression

MBs allow designers to research an expression. It is a way to find out how different shapes, images, feelings, and concepts can coexist and what the new result brings. MB designers start actively looking for different ingredients that represent the keywords and give life to the vision defined with the client. Participant LM said, *"Designers must look for images to create a story around the keywords that were identified. The images should address the previous findings."* When these ingredients are put next to each other they should convey a unique and recognizable feeling that reaches out to the target audience and clearly conveys the vision that the client and MB designer intended. As participant FS reflected, *"the completed MB should give a strong impression that goes directly into your heart as a whole."* Participant MP added: *"MBs are a new interpretation (new work of art) with a clear context."*

MBs allow researching a paradox of apparently conflicting or contradicting elements (e.g. keywords, topics, ideas). This tension is in the core of MBs as they allow visually exploring what this paradox could result in through color, shapes, and the story. Elements can form a paradox both in form (visual aspects) and content (meaning). Form refers to color, shapes, and composition, while content refers to the substance, ideas, story, or expressive effects of the elements that fit the paradox. MP gave an example: *"if the purpose of the MB is exploring shapes for packaging, MBs will allow this exploration by giving a feeling of control over the juxtaposition of contradicting shapes that fit the paradox."* Form and content may be conflicting and thus not serve the final purpose of conveying a clear and recognizable feeling. As such, making MBs is also about finding the right balance between form and content of the elements that fit the paradox.

There is always a story behind MBs. For most cases, a MB is storytelling with images. MB designers create a story that is supported by images and is based on the keywords and vision defined with the client. MB designers look at the images and see what those images tell them or how they help them build the story. *"MBs are meant to feed that story,"* said FS. The story helps convey the message that the client wants to put across and creates empathy with the target audience. Participant LM tells us that creating empathy *"is like putting yourself in someone else's shoes."* MB designers have to tell a story that addresses the culture, the environment and the situations that real people face in their daily lives. When MB designers are selecting images, they think aloud asking themselves questions such as *"Would she use this? How is her workplace?"* (LM) to assess if a given picture matches the descriptions of this person.

The elements that help build the story must be abstract, allowing MB designer, client and the audience think on a general level and get a sense of the feeling that should be conveyed. MB designers translate the abstract values and concepts that have been previously identified into a visual deliverable. MB designers must avoid applying the literal sense or meaning of objects, as it will not help the research they are undertaking. MP told us, *"If it is too literal, it is of no use."* For example, faces of famous people or images directly connected to the topics or context discussed create the effect of dragging the viewer's attention, preventing them from getting the general picture. Here lies one of the main difficulties for students making MBs: it is very difficult for them to remain abstract (Figure 21). FS said: *"students tend to be very literal, concrete and explicit."* MP added, *"For students, the picture itself is important, not the total where colors, textures, shapes and compositions create a new feeling."* McDonagh and Denton [2005] have also found that students often misunderstand MBs, *"producing them at a superficial level."* On the other hand, elements must also be real to allow the discussion to evolve around concrete things (e.g. images from magazines). They also try to incorporate textures and materials that clients can quickly relate to

Figure 21. Mood board example: 'Silence' MB put together by a design student

Design students tend to be very literal in how they use images when creating their MBs. The topic of this MB was 'sound', and the student here wanted to *"represent silence to talk about sound."* Although the idea is potentially very interesting (i.e. talking about opposites), unfortunately the author picked these images for the literal interpretations that could be made. Images of famous people (i.e. Pet Shop Boys, Jet Li) tend to drag the viewer's attention. The general composition and colors do not help convey the feeling of 'silence'.

(e.g. textures from their current environment, the company logo), transporting them to the real world. Making MBs is an exercise of jumping between being abstract and concrete again.

There are three key aspects MB designers look for in the elements they choose to create an atmosphere on the MB: color, shapes and composition. First, when MB designers are looking for images with the keywords in mind, they have an idea of the kind of atmosphere that they would like to create, and will thus look for colors in the image to better convey it. MP told us, *"A MB may have the same images, but if the colors of the images are changed, the end result will end up communicating a completely different atmosphere."* Color can be used to create an identity for a MB. FS pointed out, *"Using the corporate colors of a company or the color orange if you want to say something about Dutch culture will help the viewer receive the intended message."* Color is also an impor-

tant factor for the future design direction. FS added: *"when you look at a final design, you will not see the exact same elements in the MB, but you will expect to find the colors that MB is presenting."* Second, shapes can be used metaphorically to evoke a symbolic meaning. MP gave an example: *"People dancing with their arms and legs open in a star-like shape may represent beautiful flowers. It is irrelevant whether these are people, or if they are dancing; it is the colors, the shapes, and the posture that say something about flowers."* Shapes can also be used in a more abstract way. For example, if the concept to be represented is 'dynamic', MB designers might look for images with dynamic shapes. If shapes found in an image evoke the right symbolic meaning but the colors do not match with the rest of the images, then that image will be left out, and vice versa. Third, composition is about creating a framework in which all the elements are placed in such a way that it allows to clearly convey the message or story. It is the MB designer's job to first see if the elements match together, and later adopting a specific layout to send a message with how the different elements are placed on the board. Regarding the importance of composition, MP said that *"every brand, every trend needs a different composition."* Finding the final composition is something that takes time, therefore MBs have an incubation time. MB designers will create a first tentative composition, then leave the MB for a while there, think about it in their mind, and come back to it a week later to work on it again. By using fragments of images to create a new composition, MB designers try to avoid having copyright problems with the images they are using. As MP reflected, *"I am creating something new, something different."*

Making all elements in a MB fit together to express a feeling and create a new whole is an art. The final MB should feel as a unit with its own identity. The different elements should all coexist harmoniously, feeling like they belong together. The total should evoke the feeling instead of its details. MP told us *"every picture is present in a MB because of the relation it has with its neighbors and the total. If one image changes, everything changes. If one image is more dominant than another (i.e. because it shows a typical kind of house), it will capture the viewer's attention and they will be drawn into expecting exactly what that image is conveying."* Although connections can be made between the different elements in a MB, in the end the final general picture of the total MB should be very straightforward. FS mentioned, *"it goes directly into your heart; it is very coherent."* Creating such a strong and single impression requires a special talent that MB designers have. MB designers give a special touch to design projects by having a different way of looking at and finding the right images to give life to this unique feeling.

Communication tool

Throughout the MB making process, MB designers meet their clients to discuss the MBs establishing and keeping a special relationship with the client. This relation-

ship will ultimately define how they interact along the process. Having a good communication and keeping the clients' enthusiasm high are key issues for successful MB design.

MB designers involve their clients by giving them a sense of ownership over the MB itself. Metaphorically speaking, MB designers let the client run along with them at some stages of the process, letting them go whenever MB designers need to work on their own. Then they go back to the clients and involve them again in the process. Meetings become the points where the client is actively involved, checking if the interpretations made by the MB designer match theirs, and when they can have a say about the overall process. As FS told us, *"It gives the client the feeling that they can redirect the MB maker if they think they are losing track."* MB designers want to inspire and impress clients by communicating through images how they look at their product, company, brand, or market. They should feel comfortable with the values and design that are being aimed at. It also allows the client to say what they like, what is pretty for them, what kind of designs they like. If the client likes a specific image, the MB designer will try to find images along the chosen image. Clients must somehow relate to the MB. Adding the client's logo or using materials that remind them of their company achieve just that. At the end of the process, the original MB is given to the client and creates surprising reactions from them such as *"is that for me?"* (LM)

Clients must also feel that what the MB designer is doing for them is useful. This aspect relates to the end product itself as well as the process (i.e. the research, keywords, etc.). MB designers must identify what the most important issues for their clients are and address them in their MBs. FS said, *"The MB must address what the clients have in mind; if it is what they wanted, if it is what they were looking for. Things that make sense to them, that maybe they have not thought of yet."*

Involving the senses

MB designers involve their senses to create MBs, with their body and mind taking part in the process. It is a delicate balance between internal and external aspects that allow them to find the necessary elements for the MB. It is a state of mind where all their senses are involved.

MB designers prefer the naturalness of working with their hands to find the elements needed for the MB. They like the touch and smell of paper, or listening to music related to the feeling they are trying to research. Once they have found the right images, they like cutting the images with scissors and dragging the images to try different layouts. MB designers also prefer looking for real images on magazines. They try to avoid building MBs or editing digital images using commercial software, such as Photoshop®. They prefer using real paper and playing with the juxtaposition of images. They may use colored papers to have a better control of the overall expression of the MB, but they will not favor changing the color palette electronically on

Photoshop®. FS reflected: *"The result of editing images in Photoshop inevitably results in a new image, different from the original."*

The main reason MB designers keep their (updated) collections of magazines is for inspiration. When they look for images they use their feelings, their intuition, their skills in viewing, and their vision on things. FS said, *"It's a quick jump from the head to the heart."* Keywords set the themes for image searching. Sometimes when they are browsing the magazines they are surprised by images that introduce new themes and topics that they had not thought of before. This is not random surprise but a surprise that happens within the context of looking for images with keywords in mind. CVDB mentioned, *"With magazines, you are surprised. But looking at stock images (e.g. Image Bank, Getty Images) is less inspirational"* as the result of the searches is too literal. Another source of inspiration is music. Often when designers are working on their MBs, music will be playing in the background to set the atmosphere they are trying to reach.

Naturalistic collection

MB designers have an ongoing process of collecting images. It is a naturalistic collection of images, meaning that whenever they see an interesting image that triggers their imagination, they will collect it. Just like the naturalist Charles Darwin roaming the geography of South America who picked up interesting samples of plants and insects as he saw them, hence the name naturalistic collection. Some images can be collected because they inspire or trigger the imagination of the MB designer. Others may simply comply with aspects of expression such as textures or colors. MB designers turn to special bookstores and magazines whenever they feel they need to feed new images to their collection. They will go to great lengths for the last one or two missing images for a MB, even buying an entire book or a magazine (e.g. *View on Color* or *Provider*) that can cost up to twenty times the price of a normal magazine. Clients and designers approach MB designers because they know they have an interesting collection of images that they work with and which they will use. Another aspect about collecting is selecting elements that are not easily outdated, and that can be useful for up to five or ten years.

MB designers categorize their collections of images. For some of them it is a very structured process, keeping images in boxes under labels (e.g. human, modern, kitchen, etc.). For others, the categories are looser, keeping the complete magazines arranged in a bookshelf according to brand, types of magazines or themes, ready for later retrieval. In any case, be it a loose or structured categorization, these categories are very personal and make sense most of the time to the MB designer only. CVDB said, *"My system is my own system."* They will use keywords and labels that allow them to retrieve magazines or images. But if another MB maker would be required to work with someone else's collection, they would probably feel lost.

MB designers create piles when they retrieve images from their collection with the keywords in mind. They will usually start by looking on magazines, cutting out pictures from them and ending up with a large amount of images. This process can take up a considerable amount of time, *"usually friends and clients wonder if designers are actually working or reading the magazines."* Once they have enough images, they will start throwing images in each category (usually 30 images per concept) and start making connections with the different atmospheres. They like the easiness of piling and arranging images within the pile. Growing piles create smaller piles and sub-piles can be mixed together in a simple way. Retrieving an image that they have seen before is as simple as going to the pile and getting the image. Once the piles are ready, they also like having the overview of the whole table in one quick glance that allows them to see what they have and they can start thinking what they want to do (layout).

Finally, an important part of maintaining this collection of images is to trim it. Their collection of images is a living thing that is constantly changing, and that is continually fed with new material. However, space is limited and therefore once per year MB designers go through their collection and dispose of some material. The two main reasons for getting rid of images/magazines is that images cannot be outdated and that MB designers need space and cannot keep everything in order to grow their collections with new material. Participant LM added another reason for trimming their collection: *"Sometimes you can't see the forest for the trees."* An overly large collection of images may prevent MB designers from focusing and being able to find the right images.

MB designers look for quality images. There are five main aspects that define quality in a picture: authenticity, photography, size, paper, and trend. First, MB designers work with authentic or original pictures that help them discuss on real or concrete elements with their clients. They are looking to discuss on real elements and not on illustrations or (fake) images that were edited in the computer. MP mentioned, *"Otherwise, (clients) would look for graphic designers who are very good at that."* Second, the images should also have a similar level of photography meaning that usually the images are made by professional photographers who are aware of what the images can evoke besides just showing the elements captured by the lens. They have a special feeling for lighting, composition, contrast and the atmosphere created. CVDB mentioned that *"the level of photography is not so inspirational in non-glossy magazines because the images are very down–to-earth, it is only for the purpose of showing something. There is more fantasy to images from glossy magazines."* If for some reason they need to make a copy of an image (e.g. two interesting images on opposite sides of a page) they will make a very expensive good quality copy of it. LM told us, *"When placed on the MB, the client should not feel the difference between the copy and the originals."* Third, the images should also be large in size, at least an A4 (US

letter) format. The size of an image must be just right for a MB. Small images might go unnoticed or cause distraction when placed next to larger images on a MB. On the other hand, if an image is too big, it will tend to capture the attention of the viewer. MB designers spend considerable time and money scaling images in copy shops. They ask the operator to scale up or down in percentages which is not always easy. Fourth, paper quality means that they will look for magazines with thick, glossy paper. The quality of photography is usually directly related to the kind of paper it is printed on. With thick paper, the image on the opposite side will not be visible when placed on the MB. Finally, MB designers will look for images that show current trends in the market. Some magazines specialize in tracking trends for design, clothing, architecture, and living. LM added, *"This type of images is good to get the discussion going with the client on the type of things they like and dislike. It serves as new inspiration for design."*

3.4.9 Summary of Dutch findings

A MB is an idea development tool. MBs help both the clients and the MB designer create and transmit a mindset or vision to different stakeholders. MB designers help better define what their clients have in mind by holding a series of meetings in which they define and discuss around topics with their potential target audience in mind. The result of these discussions will be a set of keywords that outline the context of the project. The MB designer will conduct a thorough research fed by those topics, process the information and present it back to the client, which allows both parties to reach an agreement and create a common understanding. A completed MB sets a new direction for design.

A MB allows designers to research an expression. MBs allow researching the different ingredients that put together convey a unique and recognizable feeling. MBs allow researching a paradox of apparently conflicting or contradicting elements both in form (visual aspects) and content (meaning). There is always a story behind MBs, a story that helps convey the message that the client wants to put across and creates empathy with the target audience. The elements that help build the story must both be abstract to get a sense of the feeling that should be conveyed, and real to allow the discussion to evolve around concrete things. Color, shapes and composition are key aspects MB designers look for in the elements they choose to create an atmosphere on the MB. Making MBs is an art of making all elements fit nicely together to express a feeling and create a new whole.

A MB is also a communication tool for the MB designer and the client. MB designers meet their clients to discuss the MBs, establishing and keeping a special relationship with the client. This relationship will ultimately define how they interact along the process. The clients' enthusiasm is kept high by involving them throughout the process and finding useful things for them.
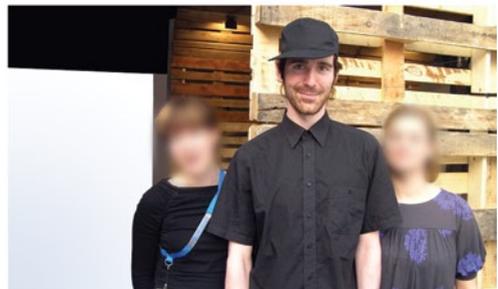
Figure 22. Finnish participants of MB interviews

EH (top-left) – Freelance textile designer

LL-K and NH (top-right) – Fashion designers. They work for Stockmann the largest Finnish department store

IH (second row-left) – Fashion designer. She owns a company for which she designs her own collections

JK and HH (second row-right) – Textile designers, they recently opened their own design agency

MB designers involve their senses to create MBs, with their body and mind taking part in the process. It is a state of mind where all their senses are involved. They prefer the naturalness of working with their hands to find the elements needed for the MB. They like the touch and smell of paper or listening to music related to the feeling they are trying to research. They like cutting the images with scissors and dragging the images on the table to see the result of different layouts. The main reason MB designers keep their (updated) collections of magazines is for inspiration.

MB designers keep a naturalistic collection of images. Whenever they see an interesting image that triggers their imagination, they will collect it. MB designers categorize their collection of images in an often-personal structure. MB designers create piles when they retrieve images with keywords in mind. They will usually start by looking on magazines, cutting out pictures from them and ending up with a large amount of images. Their collection of images is a living thing that is constantly changing, and that is continually fed with new material. Therefore in order to maintain their collection, MB designers must regularly trim it. MB designers look for quality images; images that are authentic, photographically inspiring, large in size, printed on thick glossy paper, and which show current trends.

3.5 Finnish MB interviews

In the previous contextual inquiries with Dutch designers, we were able to study why industrial designers use MBs for their work, identifying the essence of MBs. However, we wanted to compare our findings when MBs are used in other design disciplines, for different purposes, and in other countries. Therefore, our research questions for this second study with Finnish designers were 1) *are there any differences in how different areas within design make use of MBs?*, 2) *are there any differences between designers who use MBs as part of their design process as opposed to designers who only make MBs?*, and 3) *are there any differences in how MBs are used in different countries?*

3.5.1 Method

For this study the method used was empathic design [Koskinen et al. 2003]. In empathic design, a small number of cases from the main user group (expert users) are first studied in depth to get a better understanding of people. A set of hypotheses is created from the analysis of these cases. Cases from other user groups (future or

JJ-A (third row-left) – Textile designer. She has won several design awards in Finland

AA (third row-right) – Industrial designer. Managing director of a small design firm

TK (bottom-left) – Industrial designer. Colors and materials manager at Nokia

VU (bottom-right) – Industrial designer. Freelance designer and student

extreme users) are analyzed to test the emerging hypotheses. If the case does not fit the hypothesis, the hypothesis is discarded or revised, adding a new dimension to the analysis. Hypotheses are tested until the designer has an interpretation that explains the data thoroughly. Inference allows taking research in design beyond inspiration, producing understanding of the user by building an interpretation of the data.

In this case, the main user group consisted of seven fashion and textile designers while the future and extreme user groups consisted of one industrial design Master student and two industrial designers respectively.

3.5.2 Participants

Seven Finnish textile and fashion designers and three industrial designers (Figure 22) were contacted for this study. They were all experienced designers who use MBs as part of their design processes. All except one had at least 10 years experience in practice (13 years of experience on average). Although they all graduated from TAIK (University of Art and Design Helsinki), they varied in their background (textile, fashion, industrial designers), in age (between 35 and 45), and gender (6 female and 4 male). Three of them worked for large companies (i.e. Stockmann and Nokia), four of them worked in small design firms that they owned, and the rest did freelance work for large companies (e.g. Rukka, Luhta, Pentik).

3.5.3 Procedure

Ten interviews were conducted between September 19 and December 19, 2006. The procedure is similar to the one described in contextual inquiries in section 3.4.3. The main differences were connected to the content of the interview and how the interviews were captured. First, in this case all participants exclusively presented and discussed some of their previous projects for which they had used MBs. Participants usually described between two and five projects. Second, due to confidentiality issues, not all sessions were recorded on video. For those interviews in which video could not be used, notes were made instead. Otherwise pictures were made during the sessions to capture specific aspects of the work that the participants were describing. The only exception to this was the last participant whose picture was made outside the company's headquarters.

3.5.4 Interpretation

After conducting all seven interviews, the interviewer (the author) made transcripts (including photographs) and an initial categorization of the data within 48 hours after the interview. Creating this first round of interpretation right after the interviews was crucial, especially in those cases where it was not possible to capture the sessions on video. We had to process the data within that time frame to check

Figure 23. MB interviews analysis

Affinity Diagram (top-left) – Reading notes to build the affinity diagram

Categories (top-right) – Creating new categories on the table

Notes left aside (bottom-left) – Discussing notes that were left aside

Checking with Dutch findings (bottom-right) – Checking the categories from the previous study

whether or not the notes captured the essence of what participants initially meant. The transcripts varied between two and ten pages in length depending on the duration of the interview and whether we had permission to make pictures or not.

3.5.5 Checking with users

Each participant was individually approached after the interview for member validation. A summary consisting of the transcripts and the categories that were created for each participant were respectively sent to them to check the interpretation. Participants added comments to the summaries of the interviews and sent them back. Post-it® notes were used to make transcripts of the summaries. Between 41 and 51 notes were created per interview. The number of notes varied depending on the duration of the interview (between 60 and 90 minutes). Notes were color-coded (using a different Post-it® color) to identify the interview and number-coded to identify the specific note.

While we were waiting for our first seven participants to send us their comments back, we conducted three extra MB interviews with industrial designers who use MBs for their work.

3.5.6 Analysis

We assigned meaning to the summaries of the interviews through interpretation (Figure 23). The analysis team this time consisted of the interviewer (the author) plus two researchers (Dzmitry Aliakseyeu and Selene Mota), one of which had been previously involved in the analysis of the contextual inquiries. The Post-it® notes were used in several in-depth rounds of interpretation with all seven interviews from fashion and textile designers. The main goal of these interpretation rounds was to confirm and hopefully expand our initial Dutch findings. For this reason, we started by grouping notes around the same categories identified in the contextual inquiry study (e.g. client, client-MB maker, MBs, and images). Some of these categories were naturally confirmed, some were merged into existing categories, new ones emerged, and some were discarded. In the end, these categories were processed into more general findings. Between one and eight notes were left out per interview. These notes often marked changes in the discussion when participants started describing another project. Other notes were going into details about the context of the project.

3.5.7 Checking internally

We kept three interviews with industrial designers in a separate basket (cases from other user groups) away from the initial interpretation described in the previous section. By doing this, we were able to go back to the data and test our existing interpretation from the fashion and textile designers through an examination of new cases, each time posing the question *does the interpretation still work?* This procedure allowed us to enrich our interpretation, helped us to find limits to the interpretation, and make generalizations on why designers use MBs.

3.5.8 Findings

There is a great amount of overlap between our Finnish and Dutch findings. We will first share new insights from Finnish participants on the five main categories from our Dutch findings. We will then expand our findings by presenting new aspects introduced by our Finnish participants that either challenge or bring a new twist to our current understanding of MBs.

Dutch findings: Idea development

Finnish MB designers agreed with the idea of MBs being an idea development tool, one that allows the design team (including the client and other stakeholders) to

thoroughly work out together the different design possibilities. Finnish MB designers gave us new insights on how MBs are used when several people (not only one MB designer and one client) are involved in the process.

Several MB designers within a design team can first use MBs internally and later involve the client in the process. In such situations, members of the design team go through the brief, verbally discussing its contents to extract the main ideas and concepts. Later, each team member can individually collect the images that they think reflect the identified concepts. By collectively discussing the images, they can remove some of them and create one MB together. AA told us: *"Of course there is no total agreement on what the MB should be."* This way of using MBs allows the design team to internally explore the design space before meeting the client.

In large department stores, design teams with several MB designers use MBs to identify future trends for the new collections that will be produced for the department store. In such cases, there are no external clients but they rather prepare internal presentations to different stakeholders (e.g. managers, marketing, buyers) within the company. The group of designers is divided into smaller teams and brand managers are appointed for each brand. They hold general meetings to present and discuss the images selected by each team. *"We decorate the room with images. We want to hear what everybody thinks. We close the door and we try to get in the mood of the brand,"* said LLK. When the MBs are ready, they have a special trend day in which they have a presentation, play music, and serve coffee. They invite managers, as well as people from the marketing and buying divisions. Buyers later use these MBs to find the materials and products needed to create the trend. NH mentioned that, *"we need to work with pictures to explain to our buyers what we have in mind. They want to buy exactly what we are showing."*

Finnish MB designers reflected on the importance of using MBs to reach an agreement:

×   JK: *"For the client it's very good to work this way because when you have visual things it's always easier to talk about ideas and everyone knows what we are talking about, who we are making this collection for."*

×   EH: *"MBs help reach some level of understanding with the client that words only don't allow. With words we think we can understand each other but the color of a red tomato for me may be different from the color of a red tomato for someone else."*

Dutch findings: Research an expression

Finnish MB designers agreed with the notion of MBs allowing them to research an expression. Participants reflected on how inserting several MBs as part of PowerPoint presentations might affect the perception of MBs as a whole. While with a set of physical MBs it is easier to look at them and compare them in one go, with digital presentations it becomes a linear story. HH said, *"it's a problem to make (digital*

Figure 24. Set of eleven MBs for a luxurious clothing line

The apparently conflicting concepts of 'mobility', 'women drivers', and 'Russia' were explored in this set of MBs.

Each MB explored specific aspects of the collection such as 'the joining of art an science' and 'how technology

has been adjusted to be more feminine.'

presentations) that go on and you can't see the entity, but I think it helps if you take a printout of the slides and let it stand on its own." Inline with our findings, Dabner [2005] indicates that MBs have the advantage that "they can be viewed as a whole simultaneously, making comparisons and connections easier. Scrapbooks are less effective because the turning of pages creates an isolated sequence of visual experiences."

Participants gave us examples of how MBs allow them to research a paradox of apparently conflicting elements:

×   *For her 'snow fantasy' collection, IH combined snow, with nature and technology. In the background, she used the Futuro house (1968), a UFO-shaped holiday home from Finnish designer Matti Suuronen. The buildings were made of plastic. The MB was a combination between soft and technical things.*

Figure 25. Set of eleven MBs for a luxurious clothing line

Some MBs inlcuded objects (i.e. toy car wheels) to communicate aspects of mobility in the concept 'women drivers'. The wheels also had a practical use as this MB could stand on its own and thus be displayed together with the other MBs on the table.

×   *AA created a set of twenty-three MBs to create 'color worlds' for a paint manufacturer. For 'new luxury', he collected items that referred to an aesthetic idea of luxury in relation to having time and space. For 'mystical bohemian' he explored an artist-type style with mystical elements, very rich in colors.*

×   *For a luxurious clothing line, NH created a set of eleven MBs (Figures 24 & 25). The main concepts of the collection were 'mobility', 'women drivers', and 'Russia'. Each MB explored specific aspects of the collection such as 'the joining of art an science' and 'how technology has been adjusted to be more feminine.'*

×   *To propose a new color chart for tableware products, HH made a set of MBs. In one of them he explored the topic 'organic-eco-luxury'. It was important to be ecological but also to find a little sophistication into the colors, especially thinking of central European markets.*

Dutch findings: Communication tool

Finnish MB designers mostly agreed with what Dutch designers had told us about MBs and how they are used to communicate and inform the design team, clients, and other stakeholders. However they also added that sometimes in large companies MBs are made available on their Intranet to inspire designers, marketing, sales, and people in advertising. It is also common that clients and the design team itself are distributed over the globe, working in different time zones. MBs are then attached to PowerPoint presentations with some accompanying text embedded in the presentation or sometimes and extra A4 text document is attached with an explanation of the MB. HH said that, *"it had to be a presentation that could stand on its own as much as possible. (The clients) used this presentation to present it to their bosses and other people in the factory."* In both cases, Intranet or PowerPoint presentation, designers are not sure if the intended message is conveyed.

MBs are also used to communicate the final designs to technical people who will make or build the designs. JJ-A mentioned that, *"making a knitwear collection can be quite complex. It's very handy to have these MBs to show to the technical persons 'look, this is a structure I would like to have, something like this.'"* She also reflects on how the technical people do not necessarily understand the moods, feelings and abstract ideas behind the boards, but they do understand the technical aspects of the materials or knitwear shown. *"It's also very good for those guys. They are looking 'what the hell is this?' But they understand this part of the structure very well."*

Dutch findings: Involving the senses

Finnish participants agreed that MB designers must use their intuition and involve their senses to create MBs. Participants also shared a few experiences from industry in which MB designers involve other senses than just sight. LLK encourages her teams to think of smell, touch and other feelings. *"We try to capture those feelings in the images and the music that reflect the mood of the trend. The sounds could evoke the smell of the sea, and the sound of waves."* TK told us that in Nokia, they already create mood videos that include sound and animation. *"You are trying to activate relevant senses in the presentation with music, sounds, communicate color, with an effect you can feel."* In this respect, McDonagh and Denton [2005] propose the idea of incorporating movement, sound and even scents *"to offer a multi-dimensional sensorial experience, which more accurately reflect and respond to modern product design."*

Dutch findings: Naturalistic collection

Finally, Finnish MB designers also agreed with the fact that they have an ongoing process of collecting materials for their MBs. Most of these materials consist of images from magazines and occasionally MB designers use their self-made pictures. AA reflected on the importance of having the right kind of magazines: *"It is always*

important that the material that you have available re-directs (defines) what you get (the end result). Sometimes you need other types of magazines and not only interior design magazines."

Finnish MB designers brought up an interesting discussion regarding copyright issues when working with images made by other people. EH said: *"With copyright you have to be very careful what to use."* She feels it is safer to use images from magazines and books because it is public and becomes common knowledge if it is printed. But on the Internet, she feels it becomes a more personal image. *"I think it's not right."* VU added: *"You normally use parts of pictures. You can take an ad for a big fashion company and just crop like a pocket, or the fabric, or the texture, that's ok."*

Finnish findings: Defining the future

MBs help the design team in defining the future. MBs allow designers to *shake the system* and create new ideas that cannot be currently found in the market. Designers are defining the new designs and collections two years ahead of their market release date. Therefore, MB designers try to avoid including both images that show what is currently available in the market, and that come from the same domain they are designing for (e.g. not showing pictures of current mobile phones if they are trying to design the mobile phone of the future). Participant HH told us, *"there is no use in bringing products from the competitors (to the MB) because they are already known and available in the shops. Here we are talking about the future, and what will be happening some years ahead."* Participant JJ-A reflected on how she uses images to define future designs: *"It is very difficult to find these pictures because what you are seeking is new and what the images show already exists, it is always old. However, it helps tell another person what I mean, what I have in mind."* She later added: *"Discussing about these pictures is not about discussing the specific content or shape of the pictures because I want something different. I am looking for something else that I don't know yet."* McDonagh and Storer [2005] reflected on how style boards usually contain images of existing products which can "lead to an inbreeding of styles, almost visual plagiarism and may reduce lateral thinking in the inexperienced designer." Regarding the use of source images, Eckert and Stacey [2000] have found that images unconnected to the domain have the *"vagueness and ambiguity important for triggering reinterpretations."*

Finnish findings: Conflicting ideas

Finnish MB designers also mentioned how MBs allow visualizing and exploring conflicting ideas that make the team and the client think. When MB designers and clients are confronted with the MB, they are not just looking as passive spectators but they are compelled to think. When HH was explaining the 'organic-eco-luxury' MB, he said: *"(With these topics) we have to think in a little different way. 'Organic-eco-*

luxury' makes you think. There are many different solutions to find from that. If you only see the pictures, you make your own conclusions and ideas from what you see. But when you combine it with the (story), you make the tension, you make it more interesting." Participant JK added: *"You may use strong pictures with strong words which makes that awkward combination that makes you think. It really makes you and the client think."*

Finnish findings: Levels of abstraction

MB designers work on different levels of abstraction with MBs. Depending on the type and purpose of the project, they might decide to keep the discussions on a more concrete or abstract level. Keeping the discussion on an abstract level allows one's thinking to flow and come up with new ideas. Going to a too concrete level tends to narrow the number of directions for design, cutting out the possibilities that are in the vicinity of what these visualizations define. MB designers are challenged to find the right abstraction level to support communication and discussion. AA reflected on this point: *"You stay abstract to be able to work emotions, moods, atmospheres, and inspiration. If you go too concrete into the topics you are dealing with, then the attention is caught by details that are really uninteresting."* JK said, *"with this kind of work there are different levels: very concrete level (down) or very abstract level (high). It depends on the project on which level you work. If we start doing some new collection in a very new way, then we can work on a very abstract level. If we say, 'this is happening next year' then it is very clear where we are going, and we can be more concrete."*

MB designers carefully consider if using MBs will help their clients or not as not all clients are familiar with working with pictures. This also is true for designers themselves. This is why experienced designers tend to acknowledge this aspect and turn to other MB designers, stylists, or photographers who have a feeling for working with pictures. VU said, *"It depends on who you are working for (client)."* AA added, *"I have the feeling that most people are not generally capable of discussing the MBs, if you know what I mean. Without being rude, people who don't have education that has visual dimensions, they do not know the language of visuals and, to make it concrete, an engineer, not all of them but some, instead of seeing the 'technical' visual approach, they would see 'a bicycle, a knife, and a coffee maker'. That's not what we want to talk about."* JJ-A mentioned, *"It always depends on the collections and the customers. In the case of the motorcycle garment collection I made, I am not going to send any MBs to the end customers. It's no use to show any trend or fashion ideas because they have their own fashion. If I go to the motorcycling people with this (fashion MBs) they would laugh at me."* TK told us about the use of mood videos: *"For some teams it is not so good to have a mood video out there because they are too abstract for them. They prefer to talk about concrete things. The very beautiful thing is that people learn and if you work together you can request more abstraction."*

Similarly to what Dutch designers told us, MB designers mostly avoid using pictures of famous people as they would bring a new dimension and could create a distraction from the topic. TK mentioned that, *"if the face leads you to think about something specific only, then that is limiting you, it is a stereotype. We can refer to different personalities but referring to a specific face could be too limiting. It should not be forced to you nor dictated to you."* However, on very few occasions MB designers might include a picture of a famous person (e.g. Madonna) if it would sharpen the ideas behind the MB or if they wanted to make a statement. Bonnici and Proud [1998] suggest reconsidering the selection of an image "if an image jumps out, or if the eye moves around the selection."

Finnish findings: Telling a story

MBs always tell a story. MBs create a frame for MB designers to tell real stories about people and their lives; about their dreams, aspirations, and products they like. Finnish MB designers use MBs to tell stories about groups of people they are designing for, with their different mindsets and lifestyles. Each MB reflects a different lifestyle: 'artist businessman', 'romantic countryside', or 'independent Scandinavian woman.' JK said, *"it helps us think whom are we designing for, what are we doing, and why are we doing it."* JJ-A added, *"when I present these images I am telling a story about the type of woman who is using this design. Women who are happy, easy going, who take time for themselves, who have to travel but like to stay at home."* For another project, JJ-A used an old postcard she found while she was in Paris that inspired the story behind her design. *"It's not about exactly what the picture is telling me but the story I can build around the picture."*

In the case of MBs that are included as part of PowerPoint presentations, HH said: *"There is always a story that we tell, the story is strongly connected to the pictures."* However because people from other departments may see these presentations they will also include a few words. *"We can't really trust that our message goes through only by telling it in the meeting. It has to be written somehow because the material stays there and it has to be understandable. It needs to consist of pictures and words."*

Finnish findings: Several interpretations

Finnish MB designers stressed that one of the richest aspects about MBs is that they are purposely ambiguous and thus there are several possible ways to interpret them. There is no right or wrong interpretation to be made. MBs create the conditions for different people to have a productive discussion together. MB designers avoid spending too much time explaining or defending the MB, as this is not their main purpose. MB designers guide their clients through, telling the story behind it so they can understand it, but they are mostly interested in how the clients perceive it. TK told us: *"Having a constructive discussion and receiving feedback is extremely*

important. When I present a MB everybody wants to give their interpretations." AA also reflects on this point: *"Unlike written text or mathematics, we are in an area where nobody can say, 'this is exactly right.' What is important is that we have an agreement on the holistic view, that everybody has somewhat the same ideas in their head when they are talking about the topic, but then everybody can have different opinions."* New interpretations are made in this process of discussing the MB, also by the MB designer.

3.5.9 Summary of Finnish findings

Regarding the previous Dutch findings, Finnish MB designers mostly agreed with them. However, they introduced new aspects to the existing interpretation. First, they gave us new insights on how MBs are used when several people (not only one MB designer and one client) are involved in the process. For example, several MB designers within a design team can first use MBs internally and later involve the client in the process. In large department stores, design teams with several MB designers use MBs to identify future trends that are later presented to different stakeholders (e.g. managers, marketing, buyers) within the company. Second, participants told us about how MBs are inserted as slides in a digital slides presentation (e.g. PowerPoint) and how having a separate and sequential structure affects the perception of MBs as a whole. Third, participants expressed uncertainty that the right message or story is conveyed when MBs either stand alone or are inserted as part of a digital slides presentation, and are made available on the Intranet of large companies without the MB designer being able to explain the MB. Fourth, Participants also shared a few experiences from industry in which MB designers involve other senses than just sight, creating *mood videos* that also include sound and animation. Finally, Finnish MB designers also brought up an interesting discussion regarding copyright issues when working with images made by other people. The rest of the findings consist of new aspects introduced by Finnish participants.

MBs help the design team in defining the future. MBs allow designers to *shake the system* and create new ideas that cannot be currently found in the market. Designers are defining the new designs and collections two years ahead of their market release date. MB designers avoid including both images that show what is currently available in the market, and that come from the same domain they are designing for.

MB designers work on different levels of abstraction with MBs. Depending on the type and purpose of the project, they might decide to keep the discussions on a more concrete or abstract level. MB designers are challenged to find the right abstraction level to support communication and discussion. MB designers carefully consider if using MBs will help their clients or not as not all clients are familiar with working with pictures.

MBs allow visualizing and exploring conflicting ideas that make the team and the client think. When MB designers and clients are confronted with the MB, they

are not just looking as passive spectators but they are compelled to think.

MBs always tell a story. MBs create a frame for MB designers to tell real stories about people and their lives; about their dreams, aspirations, and products they like. MB designers use MBs to tell stories about groups of people they are designing for, with their different mindsets and lifestyles.

MBs have several interpretations to them. There is no right or wrong interpretation to be me made. MBs create the conditions for different people to have a productive discussion together. MB designers avoid spending too much time explaining or defending the MB, as this is not their main purpose. MB designers guide their clients through, telling the story behind it so they can understand it, but they are mostly interested in how the clients perceive it.

3.6   Discussion

As a general remark, there was a significant amount of agreement and overlap between the Dutch and Finnish findings. In the following sections we will present a few differences that we spotted along the way.

3.6.1 Design disciplines

Industrial designers used MBs in the traditional sense that we have described in this chapter, namely with the MB designer and the client involved from the very beginning in idea development of new products or services. Textile and fashion designers used MBs to define and create trends for their future collections. As such, MBs were initially used for their own inspiration, helping them identify what will be the new fashion trends in the international markets. Only later on in the process, MB designers involved their clients in the process.

3.6.2 Market size

As we mentioned in the introduction to this chapter, we spotted a difference in market size. The Dutch designers we interviewed differed in the scale of the projects and the type of clients (from global campaigns for large international companies, to small projects for the local town hall). This gave us a feeling that the Dutch market was more internationally oriented than the Finnish market. Our Finnish participants also worked for small to large clients, but they only rarely mentioned projects outside Finland.

The second main difference we found in relation to market size was connected to the purpose of using MBs. In the larger Dutch market designers could be almost exclusively devoted to making MBs. Clients would approach MB makers for their ability to work with images. These MB designers left the rest of the design process to other design professionals. In the smaller Finnish market, all designers I interviewed were exclusively using MBs as part of their own design process, which gave us richer feedback on the actual use of MBs.

3.6.3 Country

The most notable difference we found when we compared our findings was related to the Finnish participants' sense of pride for their country and the Scandinavian design tradition. When they explained their MBs to us, they would often say things like:

× *EH: "I used blue and turquoise because Finnish people love (that color), it is the color of our flag."*

× *JK: "This is the basic Scandinavian style with colors and materials that many people here in Finland use, for example white, wood and blue, the color of Finland"*

× *AA: "This MB refers to honest, Finnish, simple, and fresh food that should be attractive but easy to approach."*

They would also include in their MBs references to other famous Finnish designers through motifs or designs created by them (e.g. an Alvar Aalto chair, or the Futuro house by Matti Suuronen). Participant IH also referred to her country when she spoke about how she deals with ethical issues of her designs: *"I want to support Finnish work. So we make the production here in Finland, using Finnish materials. I don't want them to be made in the far-east where I don't know who is making the clothes and if they are getting paid enough."*

Again, differences in market size might play a role in this perception that Dutch designers do not refer to their country in their designs as often as Finnish designers do. It might also have to do with the fact that the Dutch market is more internationally oriented than the Finnish market. However, it seems that design is closer to people's everyday lives in Finland (at least in Helsinki) than in the Netherlands. Finnish design can be found everywhere in Helsinki: in its large Design district; in Alvar Aalto's buildings, chairs, and vases (Figure 26, two images at the top); also in Kaj Franck's revolutionary tableware for Iittala (Figure 26, bottom-left) that nobody had the courage to redesign as it had become an icon of Finnish design; or in Eero Aarnio's Ball Chair (Figure 26, bottom-right) that you can find in Arabia's public library to actually sit in it and read a book. All these recurring aspects came up in one way or another during the interviews. Originally from Slovenia, participant VU shared his views on Finnish design: *"There is a different attitude (here in Finland) towards design. Everybody here is really respectful about design."*

3.7 The essence of MBs

Based on the findings from the Dutch and Finnish studies, we were able to build an understanding of what MBs are.

3.7.1 Definition

We propose a definition of MBs (Figure 27) as a way to communicate our understanding on the activity that we have conducted our research on. This definition

Figure 26. Finnish designs

Paimio Chair (top-left) – Designed in 1931 by architect and designer Alvar Aalto (1898-1976)

Vase (top-right) – Also designed by Alvar Aalto in 1936

Kartio glasses (bottom-left) – Designed in 1958 by Kaj Franck (1911-1989)

Ball Chair (bottom-right) – Designed in 1966 by Eero Aarnio (1932-)

consists of eleven statements. Each statement summarizes one or more findings from our Dutch and Finnish studies. As such, next to each statement we have represented the corresponding finding it emerged from.

3.7.2 Process

Based on both studies, we also created a work-modeling diagram (Figure 28) that represents the different strategies used by MB designers in the course of the process of making MBs. The diagram consists of two main parts. The left part of the diagram represents the fraction of the process when MB designers are actively involved in making a MB. It consists of five loops: definition, collection, creation, building and presenting. On the right, we have represented the collection loop, or the MB designer's parallel ongoing activity of collecting images, regardless if they are currently involved in a MB project or not.

The process begins when the client contacts the MB designer and together they enter the definition loop where they hold a series of meetings in which they define the context of the project and begin research by building a client profile. After
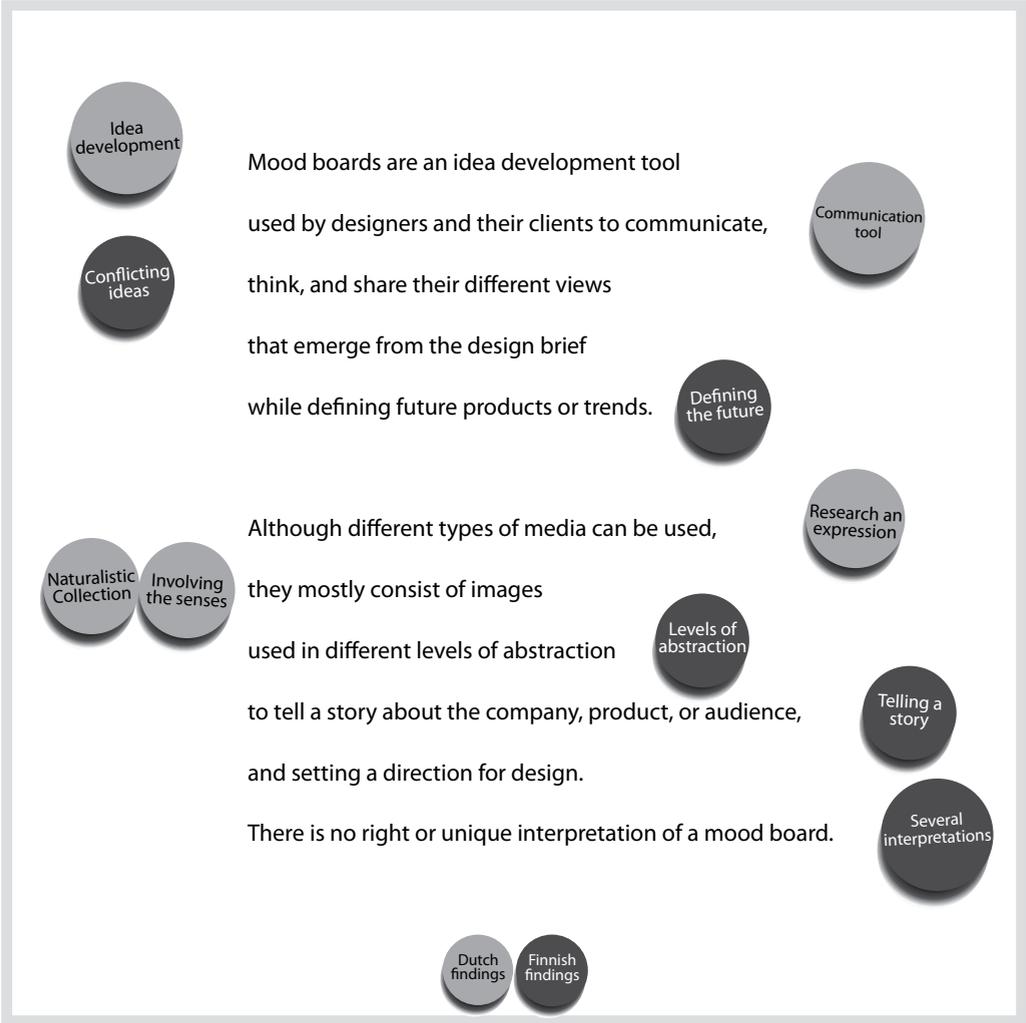
Figure 27. Definition of MBs

It consists of eleven statements that summarize one or more aspects of the Dutch and Finnish findings

Idea development

Conflicting ideas

Communication tool

Defining the future

Research an expression

Naturalistic Collection

Involving the senses

Levels of abstraction

Telling a story

Several interpretations

Dutch findings

Finnish findings

Mood boards are an idea development tool used by designers and their clients to communicate, think, and share their different views that emerge from the design brief while defining future products or trends.

Although different types of media can be used, they mostly consist of images used in different levels of abstraction to tell a story about the company, product, or audience, and setting a direction for design.

There is no right or unique interpretation of a mood board.

rounds of discussion, the MB designers enter the creation loop where they find inspiration by looking for images that trigger their imagination. Once they have found the right elements for the MB, they will build a story around them, carefully taking into account several aspects of visual composition (e.g. atmosphere, feeling, paradox, whole). MB designers and their clients hold a series of meetings to check the interpretation, and reach an agreement. In the building loop, MB designers tailor the MBs to match the client's needs. They give finishing touches to highlight certain im-
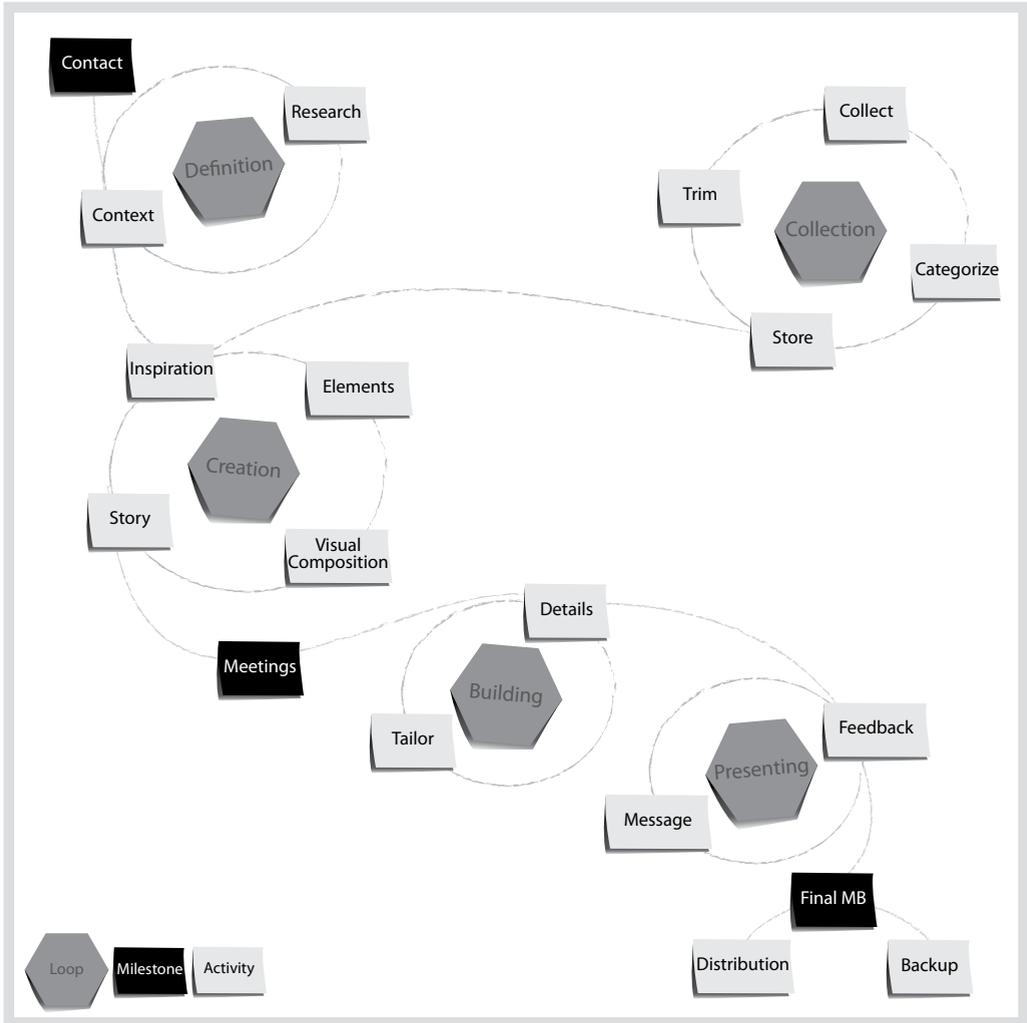
Figure 28. Work-modeling diagram

The different strategies used by MB designers are represented here. The five main loops are represented as hexagons, while the milestones and activities are shown as notes in darker and lighter shades of grey respectively

portant aspects of the MB (e.g. format, identity, text, materials). MB designers also define the final expressive details (e.g. blurring images by adding semi-transparent color paper) that will better help communicate the expression they want to achieve before mounting or gluing the final MB. In the final presenting loop, MB designers get together with their clients to check if the intended message or vision is conveyed, and to receive feedback. Finally, MB designers decide on aspects of distribution (e.g.

one MB or several booklets), and how to backup their work, especially when they give the original MB to their clients.

In the collection loop, MB designers are constantly looking for new materials for their MBs. They first collect images that trigger MB designers internally due to their visual properties. Then they must categorize and store their collection in an order that is very personal and only makes sense to them. Finally, they must periodically trim their collection to keep it updates and to allow new material to be stored.

3.7.3 The six stages

From our previous studies, we have identified six stages in the MB making process that offer opportunities for new and interesting AR designs:

×   *Collecting*
×   *Browsing*
×   *Connecting*
×   *Building*
×   *Expanding*
×   *Presenting*

First, designers begin by roughly *collecting* images from magazines, the Internet, and occasionally their own personal collection of images. This first stage relates to the collection loop of the work-modeling diagram (Figure 27). The next two stages are connected to the creation loop. Once designers feel they have enough material to work with, they will move on to the second stage, *browsing*. Here designers can spend a considerable amount of time pre-selecting images that will help them build a story or say something about the target audience, product, or company they are designing for. Third, through *connecting*, designers sort the pre-selected images in a simple and flexible way by assigning them to categories (usually up to 30 images per concept). Fourth, designers start *building* the MBs by thinking how they want to arrange the images and create different layouts. Naturally, this stage is connected to the building loop. The fifth stage, *expanding*, is not linked to a specific part of the work-modeling diagram but is a more holistic view on the complete process. Expanding refers to exploring future possibilities for supporting the creation of MBs by involving other senses (not just sight), and using other types of media (e.g. music, animation, video). In the final sixth stage, *presenting*, designers and clients meet face-to-face to share and discuss the intended story behind the MB. Designers create a single large MB or a series of smaller booklets for their clients to keep and share with other stakeholders. This last stage refers back to the presenting loop.

3.8 Considerations for a MB making tool

3.8.1 Support idea development

In our studies we have learned that mood boarding is an idea development activity that goes beyond the making of the physical MB. There is a series of steps both the MB maker and client go through before and after creating the MB itself. For example, several meetings take place along the process of making MBs to discuss and present the progress.

× *New tools should support mood boarding as an idea development activity, rather than mood boarding as the creation of the object. The tool should provide support for the different steps of the MB making process, including the activities involved before and after the actual act of building the MB.*

3.8.2 Encourage two-way communication

From our contextual inquiries we learnt that keeping a good communication between the client and the MB maker helps establish a positive relationship. This relationship will define how both parties interact throughout the process. MB makers must also present and communicate the result of their work to their clients. However, it is also important how clients perceive the MB, the feedback they provide, and the discussions triggered.

× *New tools should encourage two-way communication between the client and the MB maker needed for successful MB design.*

3.8.3 Involving the senses

MB makers involve their body and mind in the process of making MBs. It is a state of mind in which all their senses are involved allowing them to use their intuition on finding the right elements for a MB. They use touch to browse the pages of the magazines, to feel the paper, to cut images, to create piles of images and to place images when they are working on the layout of the MB. They use sight to select visual aspects that images convey (color, shapes, textures). They use hearing to work with sounds or music related to the themes or user group they are working with. They like the smell of paper when they are working with different types of paper.

× *New tools should encourage using other senses than just sight. Tactile and auditory feedback should be provided when supporting the process of making MBs.*

3.8.4 Holistic interactive space

The process of making MBs goes beyond the activities and the time spent at the designer's table. MB making is a dynamic and iterative process in which designers are constantly moving from one place to another. They are also switching activities, going from searching (e.g. images), to making (e.g. layout, gluing), then going back

again to find the missing image that fits, and also presenting.

× *New tools should create a holistic and integrated interactive design space. Instead of aiming at one interactive tool (e.g. table, wall, floor) that concentrates and provides support for all parts of the MB making process, there should be an emphasis on the importance of the whole room and the interdependence of its individual tools.*

3.8.5 Merging with the real context

Addressing the context of use is an essential part of supporting the work of designers. The process of making MBs takes place in different contexts both in and outside of the design studio. For example, in the beginning of the process, designers can spend a considerable amount of time looking for images. Designers will usually prefer going through their large collections of magazines and images while comfortably seated on a couch, in a coffee corner, or at the coffee table in a living room (when working at home), where they can freely start creating *ad hoc* piles of magazines and pictures.

× *New tools should carefully address the specific context of the activity they are aiming to provide support for. Not only should they provide support in different physical places but they should also consider the nature of the activity. For instance, some activities might require a more relaxed setting (e.g. image browsing) and others a more formal one (e.g. meetings and presentations).*

3.8.6 Flexible and intuitive interaction

From our user studies we have learned that for activities involving creation designers prefer working with their hands and with tools that allow flexibility and *intuitive interaction* (e.g. the use of pen and paper). Designers prefer working with both hands towards achieving a goal, using their hands collaboratively where one hand is doing something different than the other, as when one is using a knife and fork.

× *New tools should provide flexible and intuitive interaction through hand movements and other modalities (e.g. speech), allowing designers to perform tasks as naturally as they do now.*

3.9 Conclusions

After identifying the creation of MBs as a concrete activity, I went in depth trying to understand what the essence of MBs is. I have done that through two means: by conducting contextual inquiries with Dutch industrial designers, and MB interviews with Finnish textile and fashion designers. After these studies I have been able to come up with a definition of MBs, and a detailed description of the process of making MBs, which I have later summarized into the six main stages of the MB making process. In the process of trying to understand current design practice with

Figure 29. Mood board example: 'Essence' MB put together by the author

This MB was created as a way to communicate and summarize the main findings from the studies on MBs. Some of the topics included in this MB are 'playfulness', 'movement', 'idea development', 'intuitive interaction' and 'levels of abstraction'.

respect to MBs, I was also trying to obtain some initial ideas about how AR could possibly provide support (Figure 29). The observations I did in these two studies, also allowed me to identify my research hypothesis of *funky-design-spaces*.

Funky-design-spaces research hypothesis

Based on the findings from the previous studies I have come up with the vision of a new holistic design studio, a comfortable space for creativity that helps designers keep a good attitude. This space would create a positive effect [Norman 2004] that facilitates creative thinking in designers. Within this larger context, the process of making MBs would be supported by different *funky-design-spaces* or tools that are interconnected and help break the rhythm [Keller *et al.* 2006], stimulating designers to move around their design studios. Therefore our main research question became *could these funky-design-spaces support the creation of MBs?*

CO-DESIGN

4 Co-Design

4.1 Problem

After observing and talking with practicing designers on how they make MBs in their studios, it was time to consider some of the difficulties and opportunities of supporting the creation of MBs with AR. As a practicing designer, I felt confident of being able to take all the information I gathered during the user studies and find inspiration to propose, implement and evaluate my own solutions. All the effort I put into understanding something (apparently) as simple as MBs would now help a single designer (me) propose new concepts. There was something very un-user centered about this. There would be a large portion of the process without user involvement up until the final evaluations of the tools.

In a personal communication with Yngve Sundblad at NordiChi 2006, he said about my research process: *"People think UCD or participatory design is giving all the power to the users, and that is not the case. Of course the kind of professional knowledge (i.e. design practice) that you have, and the knowledge that technical people and program-mers have, should also be involved in (the design of solutions). But the important thing is that users are experts on their own situation, and they can give you something. In this case industrial designers can give you a lot. So I would encourage you to continue with UCD design and involve users in designing."* As I firmly believed in the UCD approach I had been following until now, I decided to fully involve users in the creative process of finding solutions to support their work by conducting co-design sessions.

4.2 Related work

Several authors have explored ways of actively involving real users and other stake-holders in the design process by inviting them to shape future artifacts in different lab settings. Some studies have also emphasized envisioning future opportunities with potential users in real context (e.g. in an office) and on the move (e.g. going to visit a client) while users perform their everyday activities in order to see both what is and what could be [Iacucci & Kuutti 2002]. This related work section covers co-design labs set up in real and artificial contexts.

4.2.1 Design labs in real context

The Design Collaboratorium [Buur & Bødker 2000] emerged as a way to overcome the limited notion of usability labs. They emphasize workshops as a vehicle for collaboration in which the real use context is addressed, the emergence of use is studied, and where different stakeholders work together in an integrated design

setting. However, because its main goal is to bring together the development team, user involvement varies greatly across projects, and in some cases users are not involved at all. Design:lab [Binder 2007] is a collaborative space of designerly exploration that takes advantage of a controlled environment and uses experimentation to go beyond observation in the real context towards prototyping possible changes. Design:lab takes place in real context (e.g. factory), combining the existing work environment (e.g. production room) with more controlled areas (e.g. factory cantina). In Design:lab authorship is shared meaning that lab partners have equal rights authoring the design work. The lab provides a setting for exploring the design space with the people involved, and thus its outcome is not the final design but rather the ground to start the actual design.

4.2.2 Design labs in artificial contexts

In the Design Lab [Brandt 2006] users and other stakeholders engage in a *conversational* design practice based on a series of design events focusing on collaborative inquiry and participatory design. During the sessions, data from field studies (i.e. video ethnography and probing [Binder 2007]) is fed in the form of design artifacts (i.e. ethnographic video-snippets in the form of cards) to bridge the gap between the lives and experiences of the different stakeholders. The sessions are driven by events, working with the design notions of *"staging, evoking, and enacting."* Johansson [2005] takes a similar approach in collaborative design sessions where designers and future users build future scenarios using data from probing and video snippets as sketching material. In the Co-Experience Environment [Ivey & Sanders 2006] users were invited to co-design a physical environment for co-experience. A small group of users with shared expertise were recruited to allow the research to evolve as an activity of equitable collaboration. Similarly to what we did, for the Co-Experience Environment participants previously worked on a probe package that later helped the designer to create two spaces. Users were invited to experience these spaces and give feedback on the overall experience. As such, in their case users were not actively involved in the design of the first two spaces but provided inspiration for the design of future co-experience environments.

4.3   Approach

4.3.1 Design labs

Practitioners from different fields of research and design have understood the importance of involving diverse groups of users in the generation phase of novel artifacts, and thus facilitating participation has become one of the cornerstones of designing [Brandt *et al.* 2005]. Researchers have started to see *everyday people* not only as the recipients of the artifacts of the design process, but as active partici-

pants in the design and production process itself, capable of adapting products to better meet their own needs [Sanders 2006a]. As a result, new methods and approaches aiming at bringing design (and research) teams together with relevant stakeholders to work collaboratively throughout the design and development process arise continuously [Buur & Bødker 2000, Johansson & Linde 2005, Brandt 2006, Ivey & Sanders 2006, Binder 2007]. While various articles discuss the benefits of using these methods, there is a lack of studies that concentrate on what is actually going on in the co-design situations.

4.3.2 Funky-design-spaces hypothesis

The previous user studies with Dutch and Finnish MB makers have shown that the process of making MBs takes place in different contexts both in and outside of the design studio (section 2.3.8). For example, in the beginning of the process, designers can spend a considerable amount of time looking for images. Designers prefer going through their large collections of magazines in a comfortable place where they can freely start creating *ad hoc* piles of magazines and pictures [Lucero *et al.* 2007]. The process of making MBs also goes beyond the activities and the time spent collecting and arranging images on a table. MB making is a dynamic and iterative process in which designers constantly switch between searching and making (e.g. layout, gluing), then going back again to find the missing image that fits. MB makers must also go out and meet their clients at different stages of the process to discuss ideas and present their results.

Based on these findings, the *funky-design-spaces* hypothesis has been defined. It is a vision for a new holistic design studio, a comfortable space that facilitates creative thinking in designers. Within this larger context, different *funky-design-spaces* or tools that are interconnected and stimulate designers to move around their design studios would support the process of making MBs. These *funky-design-spaces* should encourage breaking the rhythm and doing activities away from the designers' desks [Keller *et al.* 2006].

Practicing designers have been invited to test the *funky-design-spaces* hypothesis by co-designing these spaces with us. We (the author and Kirsikka Vaajakallio) organized *dialogue-labs* with two objectives in mind. First we wanted to present space scenarios that are mapped to the different stages of the MB making process, obtain feedback, and develop them further. As such our first research question is *how can these funky-design-spaces support the creation of MBs for designers?* The second objective was to study how different materials can support the dialogue between people when co-designing novel concepts. Therefore, our second research question is *how do different materials affect the dialogue and idea generation during co-design sessions?*

Figure 30. Finnish participants in the different stages

KB (top-left) – Designer at IDEO in collecting

KS (top-right) – Freelance industrial designer (right) in browsing

TW and JJ-L (middle-left) – Industrial designer (left), and design researcher (right) in connecting

FSW and TM (middle-right) – User interface researcher at Suunto (left), and design researcher (right) in building

AA (bottom-left) – Managing director of a small design firm in expanding

NS (bottom-right) – Freelance industrial designer in presenting

4.3.3 Dialogue-labs to test our hypothesis

In our *dialogue-labs* we brought participants into a controlled environment that mimicked a design studio. This allowed us to test the hypothesis of different *funky-design-spaces*, without confining ideas to preconceptions of what a design studio is

supposed to be like or leading them to think of their current design studio spaces. We encouraged them to think of an *ideal design studio* that could be large enough to home these different *funky-design-spaces*. Although we understand and stress the importance of context when studying the work of designers [Vaajakallio & Mattelmäki 2007], we felt that we had enough contextual information from the previous studies described in chapter 3.

4.4   Finnish co-design sessions

4.4.1 Method

We set up co-design activities in workshops, which we call *dialogue-labs* [Lucero & Vaajakallio 2008], in order to develop future ways of creating and communicating MBs together with practicing designers. In *dialogue-labs* different types of locations, tasks, and materials spark conversation and an exchange of ideas between researchers and participants (i.e. end users). By engaging in activities that rely on visual and tangible materials the complete design team involving researchers and participants is able to approach a given design problem from different entry points or perspectives and thus come up with novel design concepts. As an example, sketching is used by participants of the *dialogue-labs* to deal with the proposed design problem through the language of designing [Schön 1983], combining verbal and non-verbal expressions while sketching, by drawing and talking in parallel.

4.4.2 Participants

Eight practicing designers took part in our co-design sessions in Finland (Figure 30). Each session involved four people: two designers plus two researchers (the author and Kirsikka Vaajakallio) who acted in a double role of facilitator/designer. We primarily contacted experienced MB makers who were familiar with the ongoing research as they had previously been involved in MB interviews. All participants had at least 5 years of experience in design practice (7 years of experience on average). The participants varied in their education (university/academy), age (between 28 and 36), and gender (6 female, 2 male).

4.4.3 The dialogue-labs (FI)

The setting for the Finnish *dialogue-labs* was a large room (4m85 x 5m95 x 3m70) at the University of Art and Design Helsinki (TAIK), which was arranged to look and feel as much as possible like a real design studio including working tables, magazines, drawing materials, chairs and sofa (Figure 31). We aligned activity and process by setting the space according to the six stages of the MB making process that we previously identified (Figure 32): 1) *collecting*, 2) *browsing*, 3) *connecting*, 4) *building*, 5) *expanding*, and 6) *presenting.*

Figure 31. The Finnish dialogue-labs

A large room in TAIK was arranged to look and feel like a real design studio
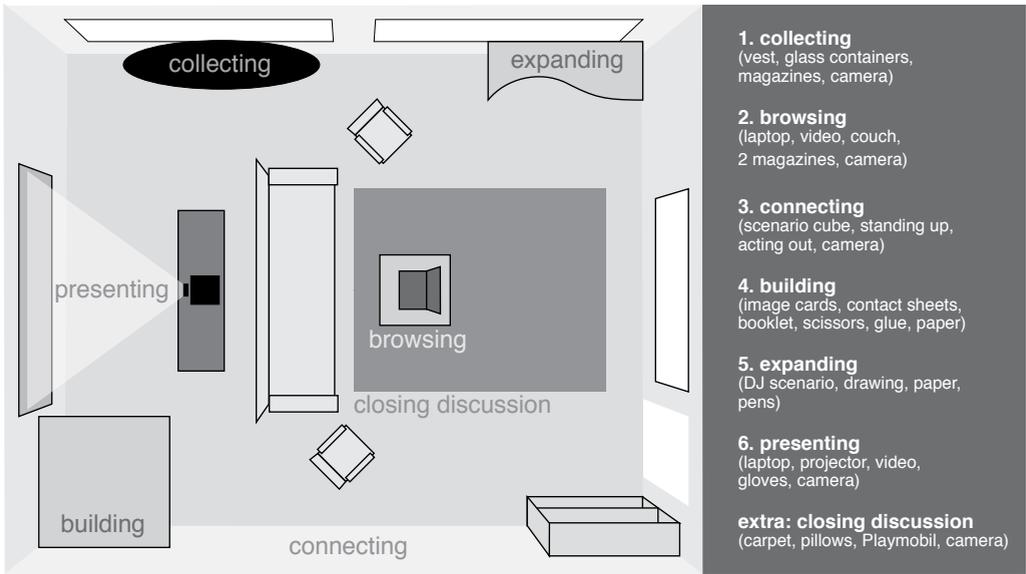
Figure 32. Map of the Finnish dialogue-labs

The space was distributed according to the six stages of the MB making process. Different materials could be found in the different stages

The aim was to obtain feedback from designers for this layout, but also to provide a basic structure for the co-design sessions in order to encourage discussion around the specific areas. The overall task was *imagine new scenarios or future ways of creating and communicating MBs*. Each stage had a corresponding location within the room, materials, and task that was formulated in an abstract-enough way so that

Figure 33. Materials used in the dialogue-labs

Cards (top-left) – Cards were available at each stage to explain the situation, the materials, and the task

Inspiring view (top-right) – A stage was set by an open window with a view on the sea for inspiration

Make Tools (middle-left) – Explorer vest, glass containers, and make tools to act-out or prototype their ideas

Connecting cube (middle-right) – Each side depicted situations where people make associations between things

Collage (bottom-left) – Images from magazines, contact sheets, and a booklet to build a MB

Sketching (bottom-right) – A real-life scenario, pens, and paper to draw new scenarios that add new senses

designers could feel inspired to think beyond how MBs are now made and used, and to think of novel ways of making them. In each stage there were cards available to indicate the situation, the materials, and the task (Figure 33, top-left).

Collecting

Designers now mainly use magazines to find contents for their MBs. However, sometimes they also need to collect other materials to express a given mood or atmosphere in their MBs, for example sound, video, smells, textures, or colors. We encouraged the team to think about these new possibilities for novel content for a MB. This stage was set by an open window with a view on the sea to help them transport themselves beyond the physical space of the design lab (Figure 33, top-right). We used the idea of *going on a hunt to collect different sensations*. Magazines were lying on the table illustrating the current situation, while more ambiguous material was used to evoke future possibilities. Abstract physical materials (Figure 33, middle-left) aiming to stimulate creating new devices or interactions included an explorer-like vest with pockets, glass containers with a cork similar to those used in chemistry class to keep the captured sensations, and a set of make tools (i.e. Velcro modeling) that allow people to prototype and express their ideas [Sanders & William 2001]. The task given was *what types of new sensations could be collected for a MB, and how could they be collected?*

Browsing

Designers now browse through their magazines searching for images for MBs. They may look for images at a table, in a coffee corner, or while seated on a couch. Two magazines were lying on a coffee table to allow reenacting how designers now browse magazines when searching for images. Additionally, we presented a video of a digital tool that allows browsing images on a coffee table [Lucero *et al.* 2007]. The video itself was shown in a coffee-corner context: the laptop on which the video was shown was set on a coffee table and participants were seated on a couch. The video is presented without sound to inspire by showing an example of browsing, but we encouraged the teams to explore beyond the contents of the video. The task was *how could different types of contents or sensations for a MB be browsed?*

Connecting

This stage refers to the process when designers select, group, pile, and make relations between different images to later include them in their MBs. In an attempt to inspire designers to think of similar situations in which people connect things, we created a scenario cube (Figure 33, middle-right). The cube measures 20 cm on each side and represents the following situations: 1) A DJ browsing different sounds, deciding which tracks make for a better mix, 2) a naturalist (e.g. Charles Darwin) adding a new specimen to his collection, 3) a cook with a rack full of different spices and flavors, 4) dancers and the set of movements that make a dance piece, 5) a tailor touching different fabrics for his latest design, and 6) a librarian visually keeping track of the available books.

The purpose of the scenario cube was to trigger discussions based on the examples contained on its six sides. This stage was set on a wall that was covered with white paper and Post-it® notes that varied in color and shape. The task was *how would you keep track and make connections with the different contents you have for a MB?*

Building

Designers have different ways to handle a collection of images prior to start building their MBs. For example, they may have images torn from magazines, or thumbnails of images downloaded from the Internet. This stage was set by a table in a corner of the room on which we placed different ways to handle a collection of images: a set of A6 cards, an A3 contact sheet with smaller pictures, and an image booklet that designers can browse by sliding images (Figure 33, bottom-left). Using the images and materials found on the table, we asked them to create a collage of different ways how designers could build a MB. We expected the different types of collections and the task of creating the collage to inspire designers to think of new solutions. The task was *how could designers put together new and different types of contents in a MB?*

Expanding

Some designers experiment with their MBs by including other senses in them such as using simple sounds or animation. We presented a real scenario proposed by the Finnish participant HH during the MB interviews. The scenario shows the situation of a designer who runs his own small company and creates MBs as part of his daily work. At night, he works as a DJ and uses his hands now to select the best bits of music. He wonders how he could add some of his musical creations to his MBs to help him better convey some of the feelings he has in mind. This scenario is presented as an A2 print on a table. We provide pens and paper so participants can draw on top of the proposed scenario, thinking of new solutions to add music or sound to MBs as a starting point (Figure 33, bottom-right). However, other types of contents or sensations could also be added to MBs (e.g. video, smell, animation, textures, etc.) The task was *what other novel elements or contents could be added to a MB to better convey a feeling or an atmosphere, and how could they be added?*

Presenting

Usually designers directly present their MBs to their clients. However, sometimes MBs stand alone as part of a PowerPoint presentation in an Intranet and the designer is unable to convey the story behind it. For this stage, we presented a video that showed a designer (the author) presenting a MB. Once again, the video itself was shown in a similar context as the one portrayed in the video: the video was projected on a wall. Sound was also omitted to prevent the team from going directly

towards the proposed solution. We provided a pair of gloves to invite the team to explore and act out different types of interaction using their hands and/or body. We asked participants to watch the video (with no sound) and try to assign (new) meaning to it. The task was *how could the story of a MB be communicated differently?*

4.4.4 Procedure

Four *co-design sessions* were conducted in August 2007 at the University of Art and Design Helsinki (TAIK). The sessions were planned for a total of two hours. The sessions consisted of six parts:

×   *Introduction – sensitizing – consent forms (15 min.)*

×   *First co-design session in pairs (45 min.)*

×   *Share and discuss outcomes (15 min.)*

×   *Second co-design session together (20 min.)*

×   *Closing discussion (15 min.)*

×   *Debriefing – questionnaires (10 min.)*

Introduction – sensitizing – consent forms (15 min.)

To create a comfortable and relaxed atmosphere, participants were greeted and introduced to each other as they arrived as if they were coming to our home [Ivey & Sanders 2006]. We began by reading together our definition of MBs (section 3.7.1) that summarizes the main findings from our Dutch and Finnish studies, followed by a short discussion to build a common understanding of the main theme of the session. We later explained the two main purposes of the session, namely studying how co-design sessions should be conducted, and obtaining ideas for future designs. We suggested them to think of technologies they could expect to be common in five years time to avoid both having wide sci-fi ideas, or ideas that are limited to current possibilities. Finally, all participants (including the researchers) read together and signed a consent form.

First co-design session in pairs (45 min.)

We formed two pairs consisting of one designer and one researcher/designer, also taking into account diversity of expertise with MBs so that highly experienced MB designers would be paired with the other researcher (Kirsikka Vaajakallio) whose primary expertise was on co-design. Based on these six stages of the MB making process, each pair was asked to think of new scenarios or novel ways of interacting with a tool that supports the creation of MBs. Participants could focus their exploration on functionality, space, or whatever came to mind. We suggested starting from the most critical stage for MBs, or the one that requires more dedication or time. Each pair spent on average 15 minutes in each of the three stages they visited.
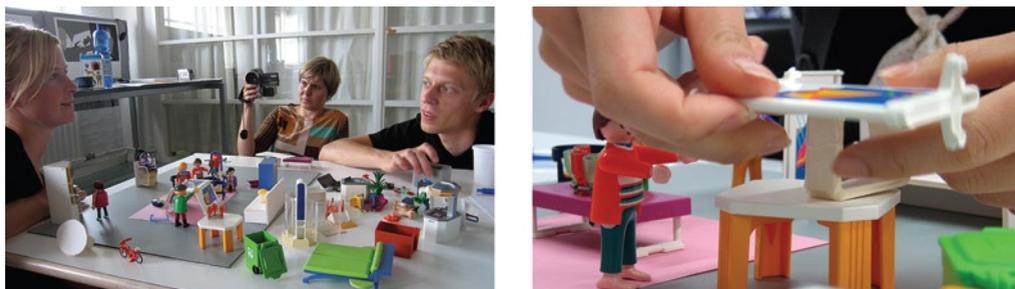
Figure 34. Playmobil® scale model of the design studio for the closing discussion

Discussion around the table (left) – Participants involved in sharing their ideas

Role-playing with the puppets and objects (right) – Participants using a puppet or piece of furniture to represent a situation

Share and discuss outcomes (15 min.)
Participants were called together as a group to share some of the ideas that emerged from the first round of discussion in pairs.

Second co-design session together (20 min.)
The complete design team elaborated upon and evaluated some of the proposed ideas.

Closing discussion (15 min.)
To round up the discussion, the complete group sat together around the coffee table for a final activity on how an *ideal design studio* could support the entire process of making MBs. A scale model of the current design studio situation using Playmobil® (Figure 34) was laid on the coffee table to stimulate playfulness with physical elements. Participants could choose to adapt the current configuration to suit their dreams, or start a new design studio from scratch.

Debriefing – questionnaires (10 min.)
Finally, all participants (including the researchers) were asked to fill-in two separate questionnaires. In the first one, we tried to assess the quality of the ideas that emerged from the session by asking participants (including the researchers) to rate each idea from every stage on a 7-point Likert scale (where -3 is very bad, 3 is very good, and 0 is neutral). Before they could give a rating, we collectively agreed on the idea that would be rated per stage by writing down the name of the idea on the questionnaire. In most cases, each pair went through different stages as the other pair. The second questionnaire consisted of assessing the helpfulness of the material by asking participants (including the researchers) to rate the different materials

Figure 35. Analysis of the ideas from the Finnish dialogue-labs

Summary of ideas (left) – Immediately after each session the main ideas were summarized in A3 format

Sketches of the ideas (right) – Example of the ideas that emerged during one of the sessions

that were available for the team on a 7-point Likert scale (where -3 is not helpful, 3 is very helpful, and 0 is neutral). In this case, the team members had to rate only the stages they had worked in, including the *closing discussion* area (Figure 32).

4.4.5 Interpretation

Immediately after each co-design session we conducted short interpretation rounds. The interpretation team consisted of the same two researchers. In this interpretation we summarized the main ideas that emerged during the sessions by means of sketches on A3 sheets of paper (Figure 35). Keywords were placed next to the sketches to describe the main ideas behind each concept. These sketches allowed us to have an initial overview on the quantity and quality of the ideas. Each A3 sheet and the ideas it contained were coded to identify the co-design session, and the number of the idea. Additionally, we discussed and wrote down some of the main discoveries we had made in relation to the process of conducting the co-design sessions.

4.4.6 Analysis

The analysis consisted of two main parts: the *process* and the *ideas*. First, we were interested in the process itself and how the way the *dialogue-labs* were prepared and conducted had affected the outcome. Therefore, we looked into the questionnaires by calculating the mean ratings and standard deviation for *quality of the ideas* and *helpfulness of the materials*. Second, we summarized the ideas that had a better potential as perceived by the participants by first looking at the highest mean ratings. We then did rounds of discussions within the analysis team to define the final concepts. We also did clustering whenever some ideas overlapped. The final concepts were summarized into sketches.

4.4.7 Findings

Funky-design-spaces hypothesis

Regarding our first research question, participants generally agreed with the notion of *funky-design-spaces*. Participants emphasized the desire of having easily convertible flexible spaces to support different types of activities. For example they mentioned the need to go outdoors to find inspiration depending on the topic of the project (e.g. market, forest, or street). In other cases such as for building, participant TW said, *"for this type of activity you should be standing up."*

With respect to the six stages of the MB making process and their corresponding location in the room, in some cases participants were a bit confused, as they did not see a clear difference between, for example, *browsing* and *connecting*. Ultimately they proposed merging the two stages together. As the sessions went by, it also became clear to both participants and researchers that expanding is not actually a separate stage of the process but runs across all stages through the task *think of new ways to create and communicate MBs*. The six stages were first identified and described in chapter 3 (section 3.7.3). *Expanding* was then included as a separate stage based on the author's ideas that later led to the *funky-design-spaces* hypothesis (section 4.3.2). However, after confronting these six stages with designers in the *dialogue-labs*, we decided to reject expanding as a separate stage. Therefore our new interpretation of the MB making process includes the following stages: 1) *collecting*, 2) *browsing*, 3) *connecting*, 4) *building*, and 5) *presenting*.

Breaking down the process of making MBs into six physically separate stages, forced participants to move about the room during the session. Participants thought these changes had been positive as they made the teams think of the whole process from different perspectives, without breaking the overall creative flow behind the session. Moreover, participants indicated that they needed these breaks to approach a new task with a fresh mind and that they would become tired if they had stayed in the same stage for 45 minutes. Thoughts that had previously come up in another stage were developed further while emphasizing on a different stage of the process.

Quality of the ideas

We split our findings regarding our second research question on *how do different materials affect the dialogue and idea generation during co-design sessions* in two: *quality of the ideas* and perceived *helpfulness of the materials*. We looked into the data from the questionnaires, namely the participant mean ratings on the quality of the ideas (Table 5). Participants first collectively agreed on what they thought was the best idea for each stage and later gave individual ratings on a 7-point Likert scale where -3 is very bad, 3 is very good, and 0 is neutral. A series of paired two-tailed t-Tests was performed for the significance of the difference between the means of the ideas.

Table 5. Finnish participant mean ratings and standard deviations on the quality of the ideas for each stage. Error bars represent the 95% confidence interval of each mean.

	Collecting	Browsing	Connecting	Building	Expanding	Presenting	Discussion
Mean	1.94	1.81	1.73	1.67	1.83	2.06	2.25
SD	.90	.95	1.05	1.03	1.07	.90	.75
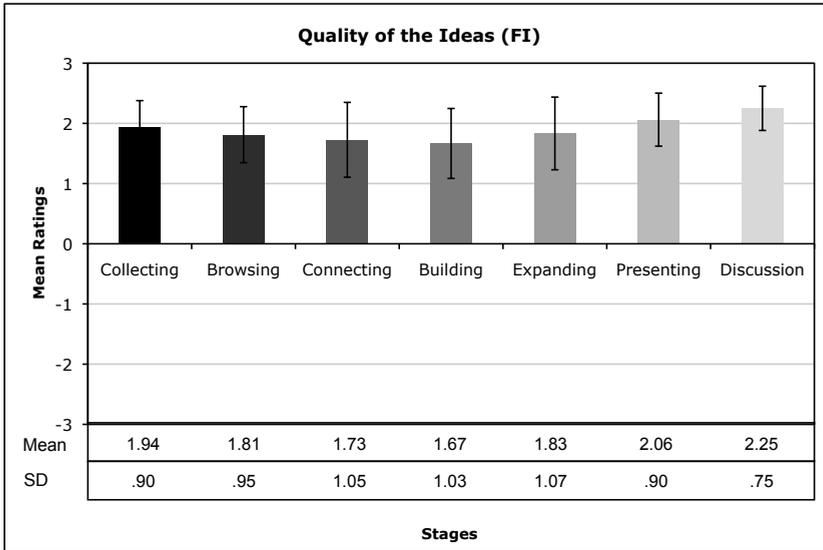
As a general remark, we can say that participants were positive about the quality of the ideas that emerged during the sessions. All mean ratings were higher or equal to 1.67, and we saw no significant difference between ideas that emerged from different stages (p > 0.05). The ideas that originated during the closing discussion received the highest rating (mean=2.25, SD=.75). The standard deviations were low and fluctuated between 0.75 and 1.07.

We were expecting the ideas that emerged from the *closing discussion* to have the highest mean rating mainly for two reasons. First, all participants collectively worked on new ideas after having shared the ideas they had previously explored as pairs. As such we expected these ideas to be better developed. Second, the ideas from the *closing discussion* were fresher in the participants' mind so it was easier for them to remember their details.

Every session brought up something new: On average we obtained 14 different ideas from each session. After the first two sessions, we did see some recurring topics starting to emerge (e.g. inspiration spaces, flexible work and presentation areas). However, until the very last session new topics were revealed.

Helpfulness of the materials

Regarding the second part of our second research question, we again looked into participants' mean ratings for the helpfulness of the materials (Table 6). Participants gave individual ratings to the materials that they used in every stage on a 7-point Likert scale where -3 is not helpful, 3 is very helpful, and 0 is neutral. A se-

ries of paired two-tailed t-Tests was performed for the significance of the difference between the means of the materials.

Table 6. Finnish mean ratings and standard deviations on the helpfulness of the materials for each stage. Error bars represent the 95% confidence interval of each mean.

Helpfulness of the Material (FI)

	Make Tools	Video A	Cube + Wall	Collage	Sketch	Video B	Playmobil
Mean	0.90	1.00	0.63	2.13	0.83	1.63	2.56
SD	1.81	.71	.86	.93	.69	.86	.50
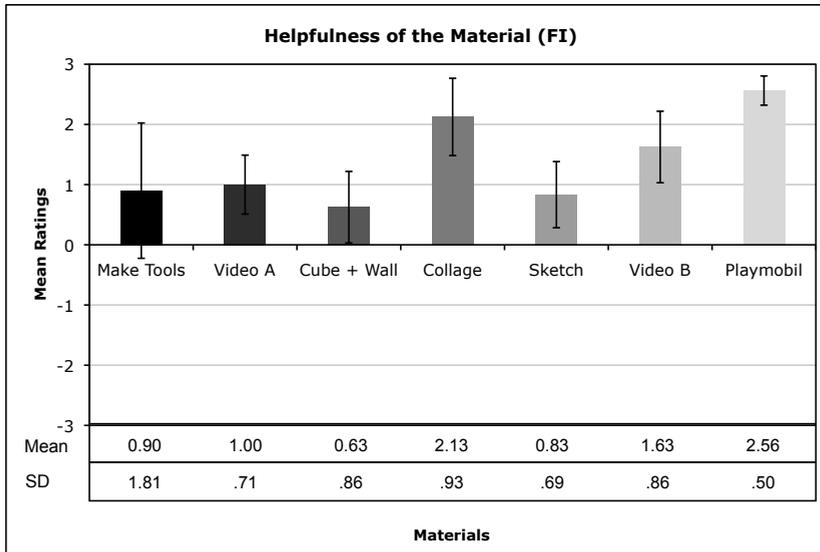
Materials

Data from the questionnaires revealed that the most helpful materials were the Playmobil® scale model (mean=2.56, SD=.50), followed by the collage (mean=2.13, SD=.93), and the two videos B (mean=1.63, SD=.86) and A (mean=1.00, SD=.71). The least helpful materials were the scenario cube with paper wall (mean=0.63, SD=.86), followed by sketching (mean=0.83, SD=.69), and make tools (mean=2.56, SD=.50), although the participants rated them all positively. Again, the standard deviations were low and fluctuated between 0.50 and 0.93, except for the make tools that had a high standard deviation of 1.81.

In general, although participants were (moderately) positive about the helpfulness of the materials used in the sessions with all mean ratings higher or equal to 0.63, this time we did see significant differences between the materials, especially for collage and the Playmobil® scale model. For collage, we observed significant differences with video A (paired t(14) = 2.55, p < 0.05), the scenario cube with paper wall (paired t(14) = 3.14, p < 0.05), and sketching (paired t(12) = 2.66, p < 0.05). For the Playmobil® scale model, we observed significant differences with make tools (paired t(24) = 3.33, p < 0.01), video A (paired t(22) = 6.01, p < 0.01), the scenario cube with paper wall (paired t(22) = 6.70, p < 0.01), sketching (paired t(20) = 6.21, p < 0.01), and video B (paired t(22) = 3.24, p < 0.01).

Participants had strong divergent opinions about the use of make tools (SD = 1.81). For some participants the make tools were used as props, gaining new meanings. For example, in one session the vest was used as a vest, but also as a scarf. However, for other participants, the vest, glasses, and make tools were intimidating and they did not know what to do with them. Originally, all materials were laid on the table at the beginning of the session. As the sessions went by we discovered that some participants felt overwhelmed by the amount of options that were given to them simultaneously. For the Dutch *dialogue-labs* sessions that followed these Finnish sessions, we decided to place all materials inside a box to prevent over stimulating participants by having them gradually discover and remove the elements from the box.

The three most helpful materials were the Playmobil® scale model (mean=2.56, SD=.50), the collage (mean=2.13, SD=.93), and video B (mean=1.63, SD=.86). First, we were unsure if participants would feel inspired to think of new scenarios using the Playmobil® scale model. We were happy to discover that people became actively involved in role-playing with the characters and the furniture. People would usually take a given puppet or piece of furniture to represent the situation they were trying to depict. In the end, as more ideas were being discussed around the table, all participants became involved and shared their views.

Second, regarding the use of collages, we discovered the need to begin the co-design sessions with a warm-up task to *break the ice* [Sleeswijk *et al.* 2005], which also allows participants to move from easier tasks to more challenging ones. Our notions from this exercise are similar in the sense that we noticed that it took some time for participants to become familiar with each other and with the situation. After going for pairs and starting the actual co-design, it took some time for the teams to reach a comfortable creative mood. In this respect, collages were chosen by participants who initially were less willing to open up and start designing. They went for an activity that was familiar to them and which made them feel more at ease.

Finally, from all the materials used to start the dialogue, videos seemed to work quite well by providing a clear and simple starting point for discussion by mutually observing what happens in the video. Participants would ask each other *"what do you think is happening?"* thus helping build upon the spirit of collaboration. The idea with the videos was not to give restrictions but instead trigger thinking. For example, in one session the video shown in the presenting stage triggered them to think beyond user interface aspects.

The least helpful material was the scenario cube with paper wall (mean=0.63, SD=.86). We discovered the paper-covered wall had created the opposite effect of the make tools. Instead of overwhelming participants by an excess of information, the wall had created a large-scale white page effect. For the Dutch *dialogue-labs* sessions after these Finnish sessions, we decided to add abstract paper shapes or Post-it®
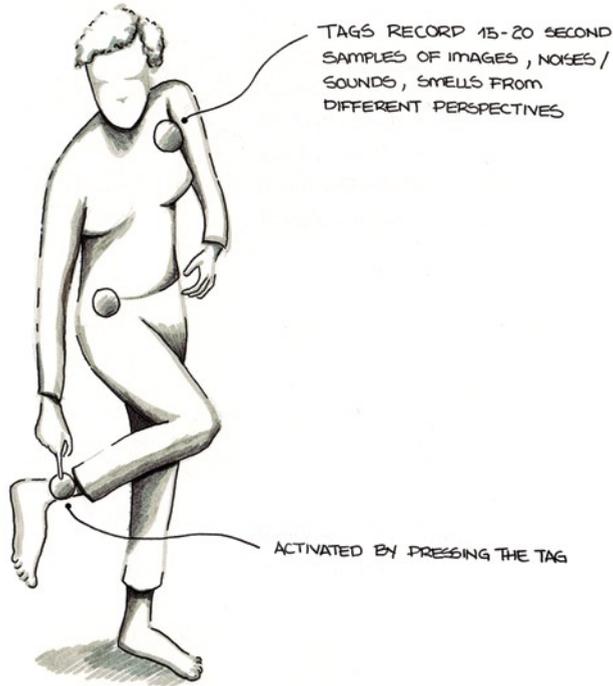
Figure 36. Tags placed on the designer's body allow collecting samples of images, sounds or smells from different perspectives

notes to give participants a few alternatives to begin their exploration and thus reduce the white page effect.

4.4.8 Design ideas

We looked into the participant mean ratings per stage to identify what Finnish participants thought were the best ideas that emerged from the different locations. The highest rated ideas per location were:

× *Collecting: tags (mean=2.5)*

× *Browsing: contextual browser (mean=2.5)*

× *Connecting: large cut and paste board (mean=2.3)*

× *Building: messy table (mean=1.75)*

× *Expanding: history of the MB (mean=2.75)*

× *Presenting: watching the stars (mean=2.5)*

× *Closing discussion: layered table (mean=2.5)*
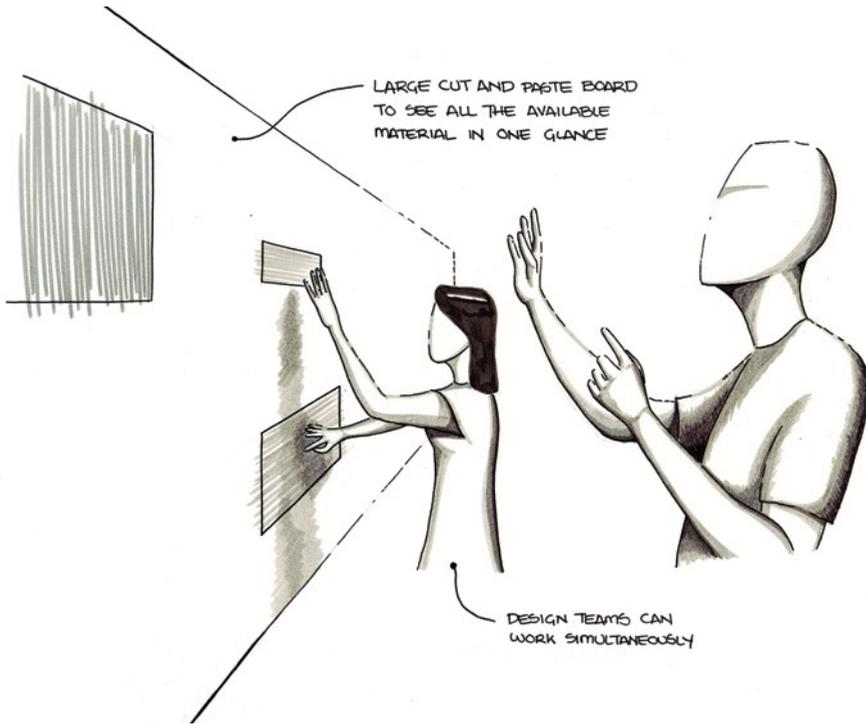
Figure 37. This large cut and paste board is used by design teams to simultaneously browse their large collections of materials, giving them an overview of all available images and sounds

Tags

This tool (Figure 36) allows collecting senses (e.g. sound, images, smell) from different areas or perspectives. MB designers place three (or more) special tags on their body (e.g. chest, hip, ankle), which are activated by pressing one of them. Three small samples are then collected from each of the three tags. Later on, MB designers can check which of the three samples that were made simultaneously best fits their needs. For example a sample of the sound of footsteps could be best collected at floor level while the sound of wind could be a more general sound collected from high above. All three sounds can be played simultaneously to check the result when they are combined. The tags also contain small cameras and thus images and short videos can be collected in a similar way. Samples are collected in a quick and natural way, as it is very important to capture the moment before it is gone. There is no detailed framing of a picture because instead MB designers have three different shots to choose from.

Contextual browser

The *contextual browser* allows MB designers to take their collection of materials wherever they want with them and start browsing it in the real context (e.g. to the forest or the open market). MB designers can find inspiration both while on the move in the environment they are currently in, and in the materials contained in their collection. For example, MB designers can explore the feelings, sounds and sensations they are getting as they are walking in a busy market place, and browse their collection in context. MB designers may also capture new materials and add them to their existing collections in this process. The system provides additional contextual information when the images are selected or captured, for example on the location (e.g. downtown Helsinki), time (e.g. fish market day), and situation (e.g. when my feet got wet because I wore slippers).

Large cut and paste board

This tool (Figure 37) consists of a large wall that allows MB designers to have all the collected material around them ready to work with it. MB designers can have a quick overview of all the materials from a distance before selecting what they need. Instead of having collections of images and sounds that are stored and hidden in folders and files, the tool can easily store and display on demand the materials on the wall, making them readily available for the MB designers to use. The tool allows easily forming custom arrangements of materials in the wall space. Design groups can make their own selections or proposals for the first impressions and rough ideas for a design problem, and later compare and discuss them. The different alternatives on the wall provide feedback and influence the ideas of the other team. The wall easily allows the duplication (or cut and paste) of images so that both teams can use a similar central image for their selection.

Messy table

This is a large interactive table that helps organize and build MBs. This table gives MB designers the opportunity to naturally handle images while receiving tactile feedback. The messy table also gives an overall feeling of creating a hand-made MB although it is made in a digital environment. A messy table allows MB designers to easily make connections between images and quickly work with a given image in isolation from others. Therefore images are not arranged in rows and columns but create a mess on the table. Images shown upside down or flipped on the reverse side can provide nice surprises. Materials look and feel real so MB designers can actually see and touch the differences in the type of paper images have been printed on (e.g. matte, glossy, or recycled). Images at the end of a messy stack of images can easily be identified simply because it has a glossy finish to it.

WATCHING THE STARS.
CLIENT AND DESIGN TEAM
LIE DOWN TOGETHER ON
THE FLOOR TO EXPERIENCE
A MOOD BOARD SHOWN
ABOVE THEM
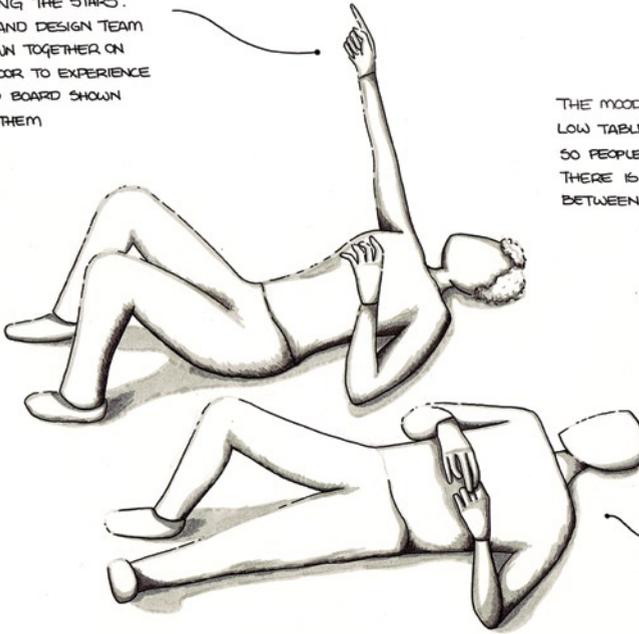
THE MOOD BOARD IS THEN SHOWN ON A
LOW TABLE IN THE CENTER OF THE ROOM
SO PEOPLE CAN SHARE THEIR EXPERIENCES.
THERE IS NO NEED TO STAND UP IN
BETWEEN TRANSITIONS

UNCONVENTIONAL WAY
OF LOOKING AT THINGS,
IT INVITES YOU TO
CHANGE YOUR PERSPECTIVE

Figure 38. Watching the stars is an invitation for designers and their clients to experience MB presentations in a relaxed and different way

History of the MB

This tool records and documents the actual creation of the MB, a very rich process in which many interesting things are said and discussed. Including the process that led to it complements the final MB. The tool captures and delivers the general mood and atmosphere of the situation as well as interesting things that are thought, said, reflected upon, and done. The tool also records the iterative distillation process of selecting, adding, and removing images, or even combining two MBs together. By means of a timeline that can be easily and quickly dragged back and forth, clients and MB designers see the formation process of the MB; where it started and where it ended up, showing all relevant information in between. The tool allows sharing important information with other people (e.g. client or stakeholders) who were not involved in the making of the MB.

Watching the stars

This tool (Figure 38) is an open invitation to experience MBs in a new way. The setup is inspired by Japanese rooms. Clients and MB designers let go of their inhibi-

tions and lie down together on the floor (e.g. Tatami mats) in a completely different sensorial experience. People adopt a more relaxed attitude to first (quietly) observe the MB that is projected above them. Lying on the floor creates a more intimate setting to observe the MB, almost like a personal cocoon. The tool projects the MB on the ceiling for a few minutes to allow people to immerse themselves into the MB. After witnessing the MB, people adopt a more active attitude to discuss and share their experiences on what they have seen. Therefore, people now sit around a low round table in the center of the room on which the MB is projected while it slowly rotates to provide different views. After the discussion the MB can be put up on the ceiling or down on the table once again, in iterative rounds of discussion.

Layered table

This tool consists of a set of adjustable surfaces (e.g. table, wall) that can be used for different purposes. Materials can be easily shared between surfaces. Different surfaces can for example be used to keep a collection of materials, to make a selection of materials, to put the discarded material (e.g. garbage surface), or for actually building the MB. A horizontal surface can easily be transformed into a vertical display to show and share its contents on the wall. Surfaces used for garbage can inspire and be a starting point for other designers working on a different project. These surfaces stimulate MB designers to be standing in an active attitude to be able to easily and rapidly share materials between surfaces. MBs can be built on a horizontal surface, be put up on a vertical surface to check the results, and back down on the horizontal surface for adjusting.

4.5   Dutch co-design sessions

4.5.1 Method

For the Dutch co-design sessions we used the same method of *dialogue-labs* [Lucero & Vaajakallio 2008] as for the previous Finnish study.

4.5.2 Participants

We invited six practicing designers and design researchers to participate in our Dutch co-design sessions (Figure 39). We used the same construct of working in two pairs involving one designer and one researcher who acted as facilitator/designer. Therefore, once again each session consisted of four participants in total. We tried to contact the four participants who helped us in our contextual inquires. As we only had four participants back then, we decided to invite designers who were experienced MB makers and/or who were familiar with the ongoing research. All participants had at least 7 years of experience in design practice (15 years of experience on average). The participants varied in their education (university/academy), age (between 30 and 46), and gender (5 male, 1 female).

Figure 39. Dutch participants in the different stages

PD (top-left) – Design researcher exploring the box contents in collecting

FP (top-right) – Freelance designer and design educator (left) watching a video in browsing

FS (middle- left) – Owner of a small design and branding consultancy (left) in connecting

IK (top-left) – Owner of a small design and research consultancy (left) in building

MDG (bottom-left) – Design researcher in expanding

MF (bottom-right) – Owner of a small design firm (left) in presenting

4.5.3 The dialogue-labs (NL)

From our previous findings of the co-design sessions in Finland we discovered that one of the stages (i.e. *expanding*) should not be considered as a separate stage. *Expanding* runs across all stages as an invitation to think of novel ways to create and

Figure 40. The Dutch dialogue-labs

The living room of the /d.search-labs was arranged to look and feel like a real design studio

1. collecting
(vest, glass containers, magazines, camera)

2. browsing
(laptop, video, couch, 2 magazines, camera)

3. connecting
(scenario cube, standing up, acting out, camera)

4. building
(image cards, contact sheets, booklet, scissors, glue, paper)

5. expanding
(DJ scenario, drawing, paper, pens)

6. presenting
(laptop, projector, video, gloves, camera)

extra: closing discussion
(carpet, pillows, Playmobil, camera)
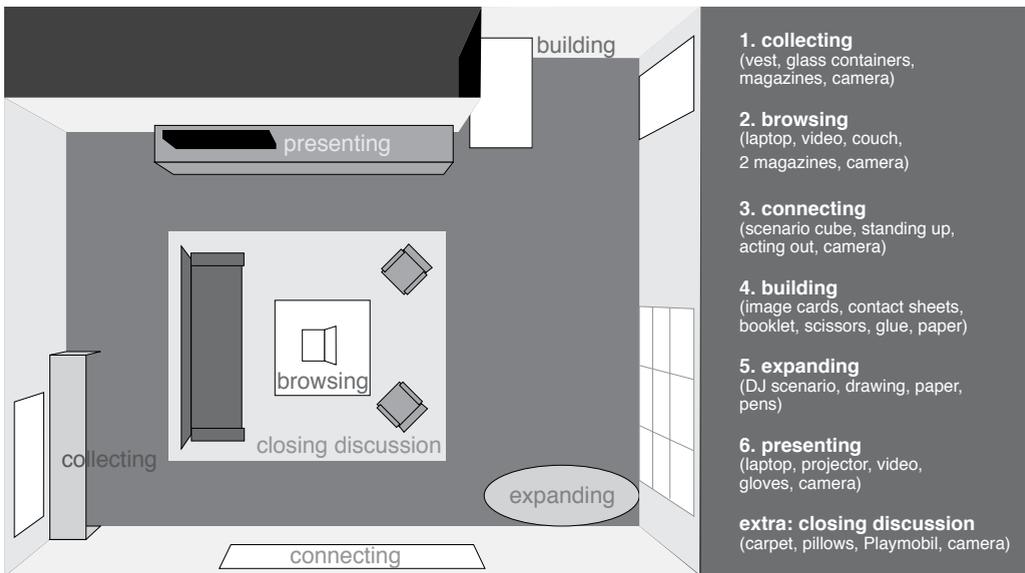
Figure 41. Map of the Dutch dialogue-labs

The space was distributed according to the six stages of the MB making process. Different materials could be found in the different stages

communicate MBs. However, in order to be able to compare the Finnish and Dutch co-design sessions, we decided not to alter the setup of the co-design sessions.

The setting for the Dutch *dialogue-labs* was the living room of the */d.search-labs* (5m05 x 6m50 x 2m45) in the Department of Industrial Design at the Eindhoven University of Technology (TU/e). The room was arranged to look and feel as much as possible like a real design studio (Figure 40) and included similar elements as

the ones described in the Finnish *dialogue-labs* (section 4.4.3). We used the same previously mentioned six stages of the MB making process, with its corresponding locations inside the room, as well as the same tasks for each stage (Figure 41). However, we introduced a few modifications in each stage, either due to differences in the dimensions of the new space, or the available furniture and hardware (e.g. flat screen TV instead of a projector). We now briefly describe some of the main differences between the Finnish and Dutch *dialogue-labs* per stage.

Collecting

Just like in the Finnish *dialogue-labs*, this stage was set by an open window to help participants open their mind and transport themselves beyond the room boundaries. Unfortunately, instead of having a nice view on the sea, the setting was somewhat less inspirational as participants were looking down on a parking lot. We turned the shades down so that participants would be mostly looking to the distant horizon where they could see a nice forest, a river, and the city skyline. Participants would still hear external sounds and a breeze of fresh air would enter the room thus providing the type of input from the outside world that we were looking for.

In the Finnish sessions we discovered that some participants were overwhelmed by the amount of options and materials available to them all at once. We wanted to see if placing the materials inside a box would prevent intimidating participants by having them gradually discover and remove the elements from the box instead (Figure 39, top-left).

Browsing

The setting for this stage was almost identical as the one described in the Finnish sessions. The setting only differed in the round shape and smaller size of the coffee table where the laptop was set.

Connecting

Similarly as for *collecting*, we made a small modification to the materials. The paper-covered wall had created a large-scale white page effect in the Finnish sessions. For the Dutch sessions after we wanted to test if adding abstract paper shapes or Post-it® notes would give participants a few alternatives to begin their exploration and thus reduce the white page effect.

Building

In this setting we slightly modified the available materials. The author had created a rich collection of large images (i.e. at least A4) from glossy magazines to make MBs and kept them in a green box. This box and the images it contained were used in the Dutch sessions for their inspirational value.

Expanding

The only change in this stage was the use of an oval-shaped table on which participants made their sketches.

Presenting

We provided the same pair of gloves and showed the same video as for the Finnish sessions. However, instead of using a projector to display the video on the wall, we used a 29-inch Philips Ambilight flat screen TV. One disadvantage of using a screen is that Finnish participants often used the projector as an extra resource for creativity and design by casting shadows using parts of their body.

4.5.4 Procedure

Three *co-design* sessions were conducted in November 2008 at the Eindhoven University of Technology (TU/e). The sessions were planned for a total of two hours and they consisted of the same six parts described in section 4.4.4 for the Finnish sessions.

4.5.5 Interpretation

Short interpretation rounds similar to the ones described in section 4.4.5 were conducted immediately after each co-design session by the two researchers who acted as facilitators/designers.

4.5.6 Analysis

We did the same analysis described in section 4.4.6 for the Finnish sessions.

4.5.7 Findings

Funky-design-spaces hypothesis

In relation to our first research question, our Dutch participants agreed with the notion of *funky-design-spaces*. During the *closing discussion* of all three sessions, participants proposed a series of ideas that were trying to introduce more flexibility in their workspaces. First, the idea of *crop rotation* could be introduced in the design studio to use specific qualities of the limited space available for different situations. Second, by simply being able to quickly change the height of tables depending on the stage of the design process. Participant PD said, *"Once you have to stand up there seems to be a lot more happening, at least with regards to moving about and constructing things. Once you sit at a table people seem more fixed on specific elements on the table."* Third, by allowing to share and display information from one area to another in a very simple and fast way that does not break the creative process. FP reflected, *"Transferring files with USB sticks is one of the big problems of the digital world. Every time you have to do all kinds of work in naming, collecting, putting things in folders, and*

sharing it with someone over and over again." Finally, and perhaps most importantly, MB designers again put an emphasis on their need to have the mental freedom to be able to go outdoors during working hours to find inspiration or simply to take a break and come back to work with a fresh mind. FS mentioned that, *"I would like to add some escape room. Sometimes when you are involved in all these projects and processes you need to have a refreshed mind to have a completely different view on what you are doing."*

Quality of the ideas

We again split our second research question in two: *quality of the ideas* and *helpfulness of the materials*. We looked into the data from the questionnaires, namely the participant mean ratings on the quality of the ideas (Table 7). Participants first collectively agreed on what they thought was the best idea for each stage and later gave individual ratings on a 7-point Likert scale where -3 is very bad, 3 is very good, and 0 is neutral. A series of paired two-tailed t-Tests was performed for the significance of the difference between the means of the ideas.

Table 7. Dutch participant mean ratings and standard deviations on the quality of the ideas for each stage. Error bars represent the 95% confidence interval of each mean.

	Collecting	Browsing	Connecting	Building	Expanding	Presenting	Discussion
Mean	1.67	1.50	0.92	1.50	1.58	2.17	2.00
SD	.75	1.12	1.11	1.12	1.66	.55	.91
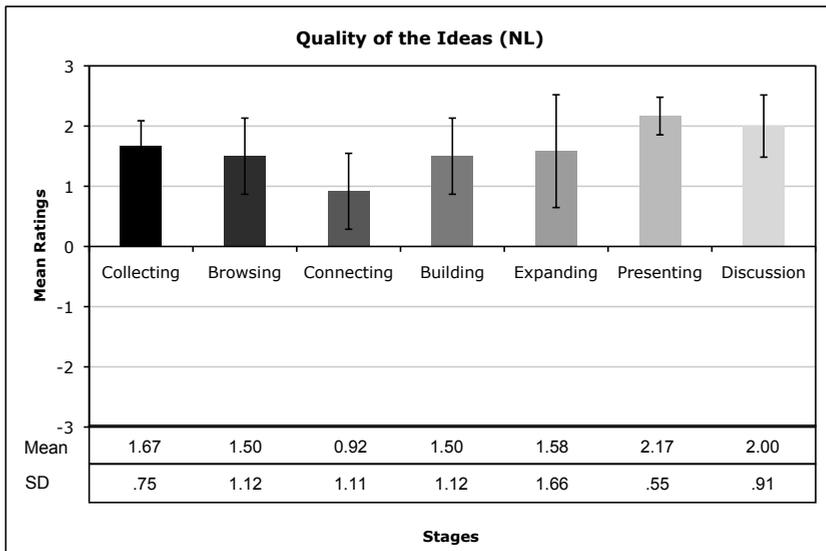
Participant mean ratings fluctuated between 0.92 and 2.17. The highest mean ratings corresponded to the ideas that originated in *presenting* (mean=2.17, SD=.55). The standard deviations were relatively low fluctuating between 0.55 and 1.66.

Once again we can say that overall participants were positive about the quality of the ideas that emerged during the sessions with mean ratings that were higher

or equal to 0.92. However, we did see two significant differences between ideas that emerged from different stages, namely between *connecting* and *presenting* (paired $t(22) = 3.3$, $p < 0.01$), and between *connecting* and the *closing discussion* (paired $t(22) = 2.5$, $p < 0.05$). Although we were again expecting the ideas that emerged from the *closing discussion* to have the highest mean rating, it turned out not to be so. Dutch participants thought with a high level of agreement (SD=.55) that the better ideas had emerged in *presenting* (mean=2.17).

Helpfulness of the materials

Regarding the second part of our second research question, we looked into participant mean ratings for the helpfulness of the materials (Table 8). Participants gave individual ratings to the materials they had used in each stage on a 7-point Likert scale where -3 is not helpful, 3 is very helpful, and 0 is neutral. A series of paired two-tailed t-Tests was performed for the significance of the difference between the means of the materials.

Table 8. Dutch participant mean ratings and standard deviations on the helpfulness of the materials for each stage. Error bars represent the 95% confidence interval of each mean.

	Make Tools	Video A	Cube + Wall	Collage	Sketch	Video B	Playmobil
Mean	1.17	1.50	1.00	0.50	1.33	2.00	1.75
SD	1.07	.50	1.00	1.98	1.49	.58	1.01
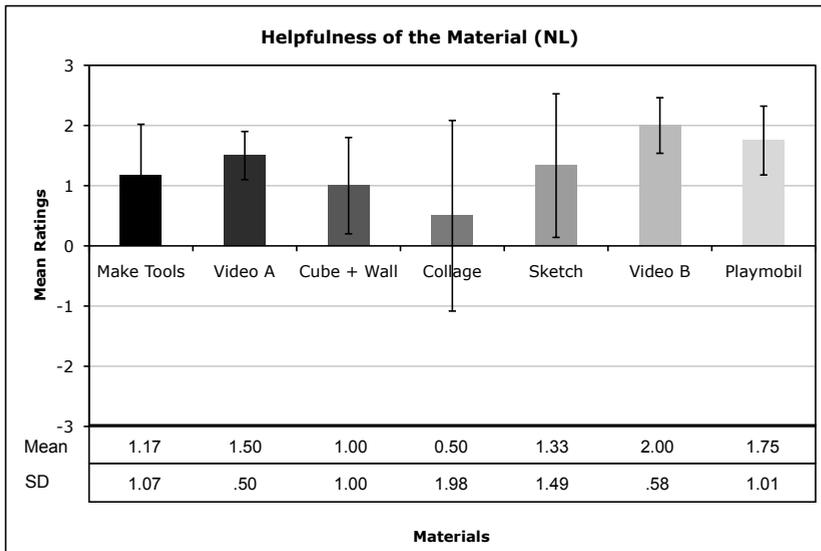
The mean ratings revealed that the most helpful materials were the two videos B (mean=2.00, SD=.58) and A (mean=1.50, SD=.50), followed by the Playmobil® scale model (mean=1.75, SD=1.01), and sketching (mean=1.33, SD=1.49). The least helpful materials were the collage (mean=0.50, SD=1.98), followed by the scenario cube with paper wall (mean=1.00, SD=1.00), and make tools (mean=1.17, SD=1.07),

although the participants rated them all positively. Here we found a great deal of difference in the agreement across participants that fluctuated between 1.00 and 1.98, except for the two videos A and B that had low standard deviations of 0.50 and 0.58 respectively.

Participants were in general (moderately) positive about the helpfulness of the materials used in the sessions with all mean ratings higher or equal to 0.50. We observed no significant differences between the helpfulness of the materials (p > 0.05). However we saw that Dutch participants used materials somewhat differently than their Finnish counterpart. For example, while collages had been rated highly by Finnish participants (mean=2.13, SD=.93), Dutch participants gave it the lowest mean rating (mean=0.50, SD=1.98). For some Dutch participants the use of collage was similarly helpful as for the Finnish participants. However we observed that while Finnish participants were actively involved in creating a collage, Dutch participants generally used the materials but never engaged in actually making a collage, which could explain the difference in mean ratings.

With regards to the use of make tools, we decided to place the materials inside a single box to avoid overwhelming participants. This decision had a positive effect on participants as can be seen in the higher mean rating (mean=1.17, SD=1.07) when compared to the Finnish findings (mean=0.90, SD=1.81). We also observed that hiding things in the box sparked the curiosity of participants who gradually unveiled some of the materials they found in the box (Figure 39, top-left).

Regarding the most helpful materials, participants thought video B was the most helpful (mean=2.00, SD=.58). The main difference between videos A and B is how abstract or concrete its contents are. The *presenting* video does not show a working tool or an interaction but instead shows a designer (i.e. me) standing in front of a MB while making a presentation. In line with Brandt and Grunnet [2000], we found that simple, more generic, and abstract representations seem to open up solution space.

Regarding the scenario cube with paper wall, we placed a few abstract-shaped Post-it® notes (e.g. circles, triangles, flowers) to reduce the white page effect we had observed in the previous Finnish sessions. The higher mean ratings (mean=1.00, SD=1.00) when compared to the Finnish study (mean=0.63, SD=0.86) show that this decision positively affected participants.

4.5.8 Design ideas

We looked into the participant mean ratings per stage to identify what Dutch participants thought were the best ideas that emerged from the different locations. The highest rated ideas per location were:

- × *Collecting: collecting box (mean=2.0)*
- × *Browsing: collective tagging (mean=2.0)*
- × *Connecting: exploration wall (mean=2.0)*
- × *Building: mood sketching (mean=2.75)*
- × *Expanding: living MB (mean=2.75)*
- × *Presenting: presentation recorder (mean=1.75)*
- × *Closing discussion: take a break (mean=2.5)*

Collecting box

This tool consists of a box you can go out with to collect different materials for your MBs. It contains special collecting pads that collect smell by rubbing them against an object or surface. The collecting pads can then be cut into different shapes or given the color of the smell to include them in a MB. The box can also create different textured surfaces (e.g. sanding paper, leather) to help MB designers explain to their clients what something would feel like to the touch (e.g. how the interior of a car would feel). Small marbles collect sounds by pressing them. Pressing them again releases the sound. Clients on the other side of the world can feel the sounds, smells, and textures using a similar *collecting box*. The toolbox is easy to transport and helps preserve the samples collected for later use. Once several samples have been collected, the toolbox also allows MB designers to create and combine new materials for their MBs. The toolbox and its contents are inspiring to look at and handle; something MB designers can proudly show their clients. Including new senses into the MB can help reduce the number of pictures needed.

Collective tagging

This tool provides support for going through piles of images or magazines that you or other designers have created. This system is inspired by the current use of Post-it® notes to mark interesting pictures. MB designers can add tags to indicate that an image is interesting for them. The number of tags added indicates how many projects a magazine has been used for. Tags help MB designers quickly remember what made a given image interesting to them. Other designers also add their own tags. Tags are shared with other people to check how different people perceive similar interesting images. Some MB designers may want to avoid images that have a peak in popularity and search in unexplored areas. Similarly, piles of magazines made for different projects can be saved as a tag. MB designers can browse tags of piles made in other design studios or pre-defined piles with specific interests.

Exploration wall

This tool consists of a large digital wall that allows design teams to first cluster different types of media. Abstract representations or shapes stand for images, sounds,

MOOD SKETCHING IS A QUICK AND INEXPENSIVE WAY OF MAKING MOOD BOARDS USING A PDA OR MOBILE PHONE

THE MOODS ARE SKETCHED ON THE DEVICE'S SCREEN BY SELECTING , MOVING ,ROTATING AND ENLARGING THE IMAGES
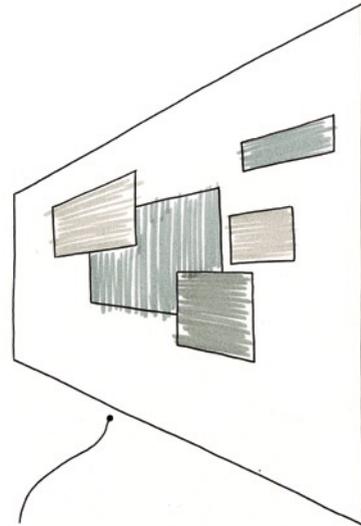
THE MOOD SKETCH IS THEN PUT UP ON THE WALL FOR COMMENTS AND SO A NEW MOOD SKETCH CAN BE MADE

Figure 42. In mood sketching designers use portable devices to quickly and impulsively create several MBs that they put up on the wall for feedback and discussion

smells, or textures. The tool allows easily making connections between media by dragging elements together, linking, and annotating them. Images can be represented as thumbnails that are enlarged when selected. Design teams can explore sounds collectively and individually. Two persons can approach different parts of the wall and simultaneously play a given sound in a low volume. Approaching the wall and scratching its surface allows designers to smell aromas. The *exploration wall* also allows ordering the available material collectively. The wall gives an overview of materials that are later used to create a narrative that unfolds. This narrative dictates how the different elements are connected. Besides being a wall with an overview of materials and temporal or narrative clustering, it is also a mixing wall to try out combinations and where different possibilities can be explored.

Mood sketching

This tool supports the designer's creative impulses by allowing them to create several MBs in a very quick and inexpensive way. MB designers use a PDA or iPhone-sized device to quickly and intuitively sketch different moods, selecting, moving,

rotating, and enlarging images on the screen. It only takes them one or two minutes to create the MB. The sketched MB is then shared and put up on a digital wall so a new one can be made. As the original size of the sketched MB is very small, it looks pixelated and very ugly on the large screen when enlarged. However, people look at it as a sketch of a mood so it is acceptable. Colleagues can comment on the mood sketches hanging on the wall. MB designers can then stop, look at the results and analyze which strategy (e.g. starting with a background, this is status quo, a top-down approach) or parts of mood sketches worked best. So MB designers can start with a given strategy they have chosen and make new mood sketches in quick succession. When designers are happy with a few mood sketches, then the materials used in them pop up on a large horizontal table in full resolution for fine-tuning, creating a final MB.

The tool (Figure 42) supports the practice of *crit* in design or art schools where students put up their sketches, collages or designs on the wall and then they go around as a class discussing each person's work. *Crit* is short for criticism and is also practiced among design colleagues to receive feedback. The sketches and MBs that are put up become public, the ideas bounce off the wall, and become the weight for the conversation and the dialogue.

Living MB

The living MB is a tool that makes MBs interactive living objects that provide inspiration and surprise. The MB designer creates a core MB with a few basic elements, plus alternatives or associative images, movies or sounds for each of the basic elements. The MB is displayed on a wall and changes over time reacting on the context depending if there are more or less people around, if the weather changes the amount of light in the room, or if it has remained unchanged for some time. Elements can also change or move to challenge the MB designer. People can keep on adding new materials or making associations to the basic elements. The tool can also suggest new associations based on the basic elements. The *living MB* provides inspiration for its creator and other designers by catching their attention and defining the atmosphere they work in.

Presentation recorder

This tool (Figure 43) helps the client and MB designer interactively communicate and later remember ongoing discussions. The tool captures the presentation given by the MB designer and shares it with the client to also involve them in the process. It becomes some kind of contract with the agreement to follow a given path for the remainder of the project. This pre-editing tool only captures movements and sounds to see the discussion. Therefore, no video and no faces are captured or displayed. The client can then take specific things in the presentation, point at them

THE PRESENTATION RECORDER CAPTURES THE SOUNDS AND MOVEMENTS THAT ARE MADE DURING MOOD BOARD PRESENTATIONS
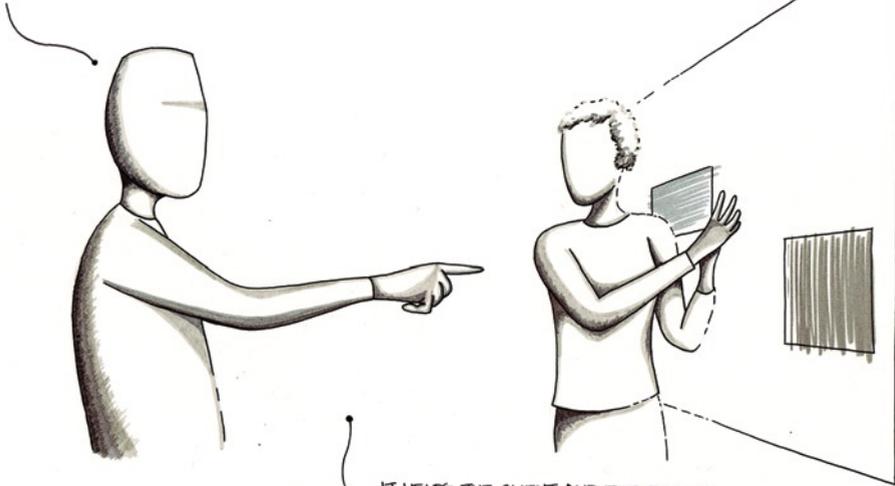
IT HELPS THE CLIENT AND THE DESIGN TEAM REMEMBER ONGOING DISCUSSIONS AND PREVIOUS AGREEMENTS BY CAPTURING SNAPSHOTS OF THE DIFFERENT STAGES OF THE DISCUSSION

Figure 43. The presentation recorder captures sounds and movements made during a MB presentation, serving as a reminder of previous agreements

and change them. The client will shuffle around the MBs and the tool captures snapshots of the different stages of the discussion. MB making then becomes a closer cooperation between the MB designer and the client who become a team.

Take a break

Take a break (Figure 44) responds to the designers' need to have a space where they can momentarily disconnect from work, do something in there, and come back with a fresh mind. This comfortable space creates a feeling of disconnection from the world, similar to that of taking a shower or lying flat in bed. The idea is to provide a free connection to the outside world, if not physically at least mentally. Designers feel free to go to this isolated space for a creative moment of doing nothing while having some privacy and not being disturbed by others. An inspiration for this space could be Eero Aarnio's Ball Chair (1966) (Figure 26, bottom-right), which is described as a "room within a room with a cozy and calm atmosphere, protecting outside noises and giving a private space for relaxing."
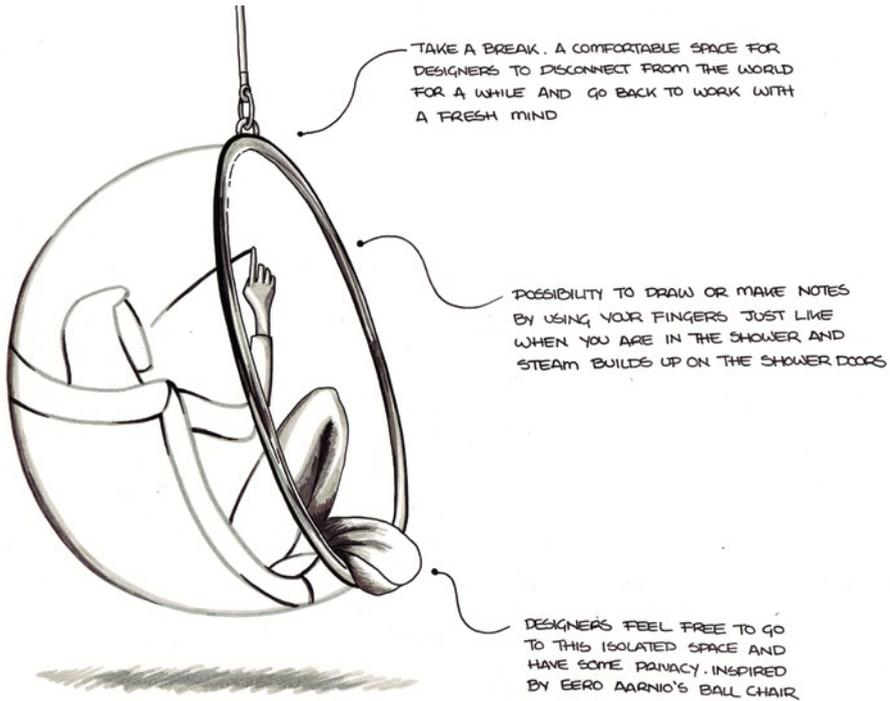
Figure 44. Take a break corresponds to the designers' need for a comfortable place where they feel free to rest and unwind for a while before heading back to work now with a fresh mind

4.6   Overall findings (FI + NL)

4.6.1 Funky-design-spaces hypothesis

In relation to our first research question, both our Finnish and Dutch participants generally agreed with the notion of *funky-design-spaces* that stimulate designers to move away from their desk to support the process of making MBs. Both groups expressed in their own way the need to have easily convertible flexible spaces that support different activities both inside and out of their design studios. The rich diversity of design ideas proposed by the teams also point in that direction. They almost suggested a mentality change for their work culture where going outside during work hours to find inspiration or to break away from work is seen as socially acceptable (now it is not). What we confirmed is that MB making is an activity that requires designers to break away from their desk.

4.6.2 Quality of the ideas

We jointly calculated the mean ratings and standard deviations for our Finnish (n=16) and Dutch (n=12) participants to have a general impression of our findings (Table 9). A series of paired two-tailed t-tests was performed for the significance of the difference between the means of the ideas.

Table 9 Finnish and Dutch participant mean ratings and standard deviations on the quality of the ideas for each stage. Error bars represent the 95% confidence interval of each mean.

	Collecting	Browsing	Connecting	Building	Expanding	Presenting	Discussion
Mean	1.82	1.68	1.30	1.58	1.71	2.11	2.14
SD	.85	1.04	1.16	1.08	1.40	.77	.83
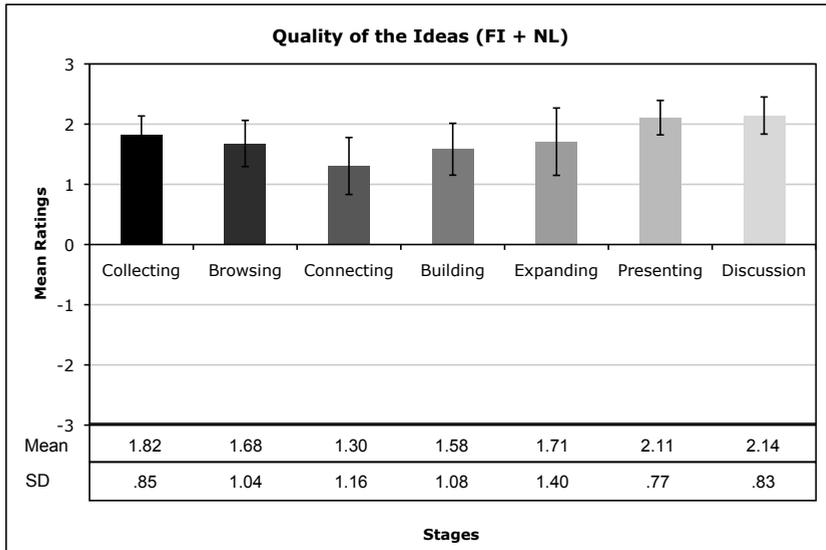
Overall, participants were positive about the *quality of the ideas* that were created in the *dialogue-labs*. Participant mean ratings fluctuated between 1.30 and 2.14. We observed three significant differences between the ideas that originated from the different stages, namely between *connecting* and *presenting* (paired t(49) = 2.9, p < 0.01), between *connecting* and the *closing discussion* (paired t(49) = 2.9, p < 0.01), and between *building* and the *closing discussion* (paired t(50) = 2.1, p < 0.05).

The ideas that originated during the *closing discussion* received the highest mean ratings (mean=2.14, SD=.83), followed closely by *presenting* (mean=2.11, SD=.77). The standard deviations were low and fluctuated between 0.77 and 1.16, except for *expanding* (SD=1.40). This data suggests that the *dialogue-labs* had a positive influence on the creation of ideas. Participants were positive about the outcome generated during the sessions, both in terms of quality and quantity of the ideas.

4.6.3 Helpfulness of the materials

We also jointly calculated the mean ratings for our Finnish (n=16) and Dutch (n=12) participants with regards to the helpfulness of the materials (Table 10). A

series of paired two-tailed t-tests was performed for the significance of the difference between the means of the ideas.

Table 10 Finnish and Dutch participant mean ratings and standard deviations on the helpfulness of the materials for each stage. Error bars represent the 95% confidence interval of each mean.


Helpfulness of the Material (FI + NL)

	Make Tools	Video A	Cube + Wall	Collage	Sketch	Video B	Playmobil
Mean	1.00	1.21	0.79	1.43	1.08	1.79	2.21
SD	1.58	.67	.94	1.68	1.19	.77	.86
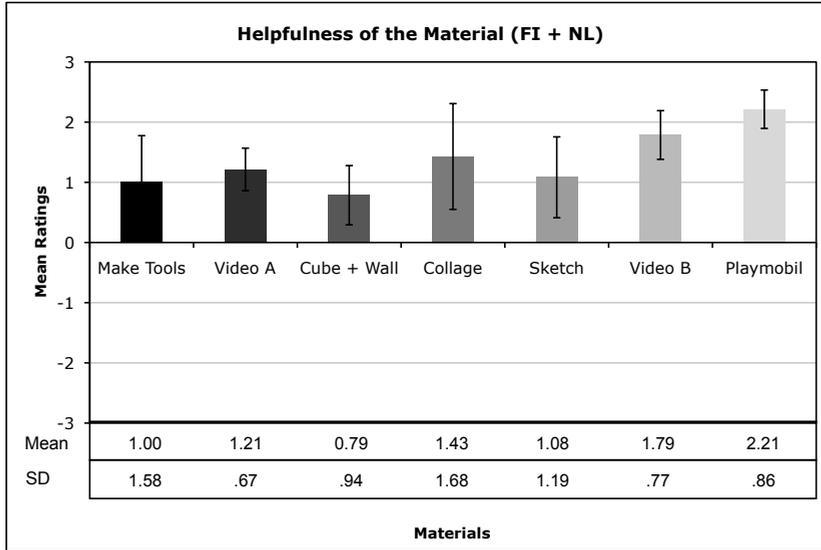
Generally speaking, participants were positive about the *helpfulness of the materials*, although less so than for the *quality of the ideas*. We found significant differences between the materials, especially for video B and the Playmobil® scale model. For video B, we observed a significant difference with the scenario cube with paper wall (paired t(26) = 2.96, p < 0.01). For the Playmobil® scale model, we observed significant differences with make tools (paired t(42) = 3.22, p < 0.01), video A (paired t(40) = 3.71, p < 0.01), the scenario cube with paper wall (paired t(40) = 4.79, p < 0.01), and sketching (paired t(38) = 3.27, p < 0.01). All mean ratings were higher or equal than 1.00, except for the scenario cube with paper wall (mean=0.79, SD=.94). The use of the Playmobil® scale model (mean=2.21, SD=.86), and videos B (mean=1.79, SD=.77) and A (mean=1.21, SD=.67) received the highest mean ratings and had the highest level of agreement, helping participants mostly to discuss, present, and generate new ideas. Participants agreed on sketching (mean=1.08, SD=1.19) and the scenario cube with paper wall (mean=0.79, SD=.94) composing a second less useful group of materials. Finally, although the collage and make tools had higher mean ratings than the previous group (mean=1.43 and mean=1.00 respectively), due to the high level of disagreement (SD=1.68 and SD=1.58 respectively), we cannot conclusively say something about their usefulness. The data shows that for some
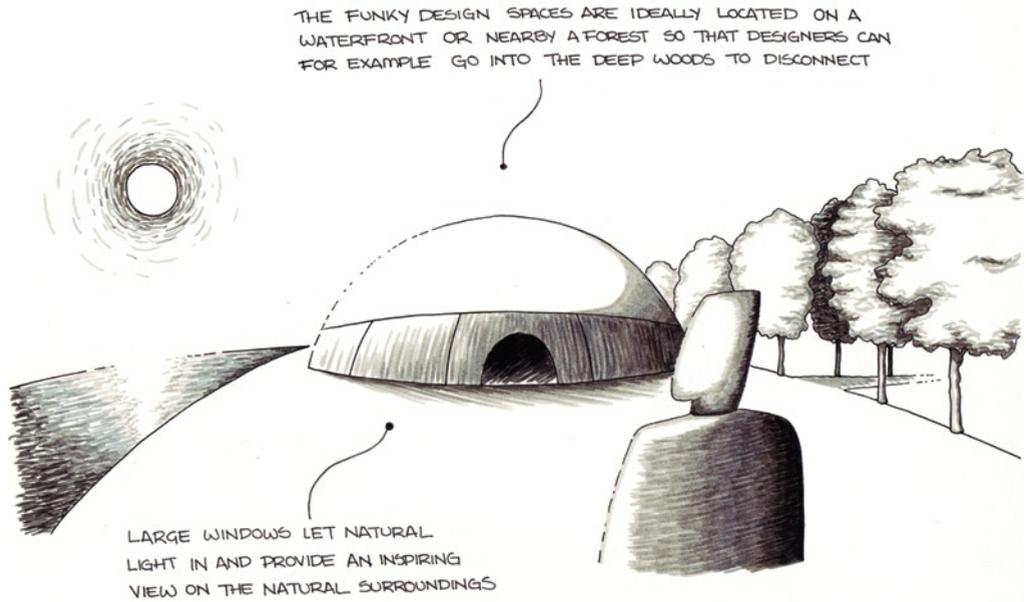
**Figure 45. The funky-design-spaces environment**

The spaces are located in a natural surrounding where designers can disconnect from the world by, for example, going into the deep woods. Large windows provide a direct view on the natural surroundings and allow natural light to energize designers

participants they were really useful and for others not.

Finally, we also did a regression analysis to examine the relationship between the perceived helpfulness of the materials and the perceived quality of the ideas. The analysis shows the perceived helpfulness of the material had a significant impact on the perceived quality of the ideas that emerged from each co-design session ($\beta=.211$, $p<.027$, $R^2=.045$). Although the quality of the material had a significant impact on the quality of the emerging ideas, one can note that it only accounted for 4,5% of the variance in the data. It becomes apparent that the perceived quality of ideas that emerge from co-design sessions is influenced by a multitude of factors and these could be aspects such as the perceived involvement in the creation of the idea or the perceived cooperation between co-design participants.

4.6.4 Design ideas

There is a large amount of overlap between the Finnish and Dutch findings. We have

INSIDE, THE FUNKY DESIGN SPACES CREATE A RELAXED AND COMFORTABLE ATMOSPHERE WHERE DESIGNERS FEEL THAT THEY BELONG TO THE TEAM BUT CAN ALSO FREELY ESCAPE FOR A QUIET MOMENT

ADJUSTABLE MULTI-PURPOSE SURFACES CAN BE USED TO EASILY DISPLAY AND SHARE INFORMATION, AS WELL AS RE-ORGANIZED ACCORDING TO DIFFERENT SITUATIONS OR PROJECTS
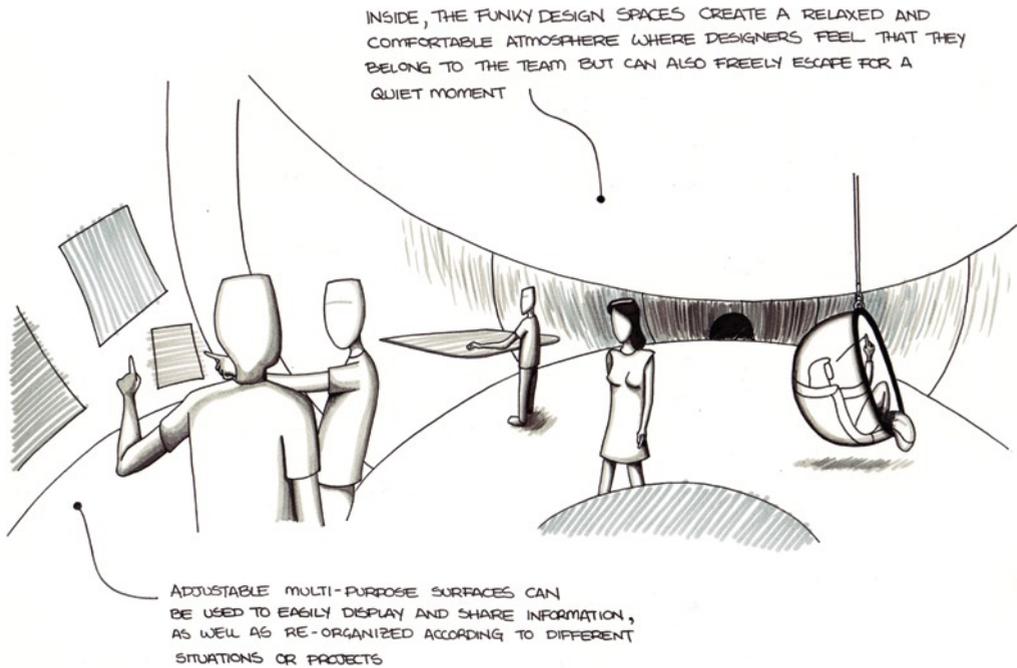
Figure 46. Inside the funky-design-spaces

The spaces create a relaxed and comfortable atmosphere where designers can engage in individual activities as well as creative collaboration. Designers feel that they belong to a larger team but they can also have a moment for themselves when needed. Adjustable multi-purpose surfaces can be used to easily display and share informa-tion. These surfaces can be assigned for different uses

already discussed the general similarities we found in both studies with respect to the *funky-design-spaces* hypothesis (section 4.6.1). Now, regarding the specific ideas generated during the sessions, we also found characteristics in common. These ideas have been summarized into three groups: *flexible spaces (environment), intuitive making (activities),* and *recording encounters (process)*. By means of this summary, we will try to put in perspective how the individual ideas found in both studies fit the larger context of the *funky-design-spaces* (Figure 48).

Flexible spaces (environment)
Ideas like the *contextual browser, watching the stars*, the *layered table*, *mood sketching*, *living MB* and *take a break* belong to a first group where MB designers request more freedom and flexibility to do their current activities. Most of these ideas explicitly

STORING AND MOVING INFORMATION BETWEEN FUNKY
DESIGN SPACES IS ACHIEVED IN A VERY SIMPLE WAY
TO AVOID BREAKING THE CREATIVE PROCESS

DESIGNERS USE A BALL THAT THEY JUST BOUNCE ON THE WALL
TO COLLECT THE INFORMATION AND THEN ROLL THE BALL ON
ANOTHER SURFACE TO DISPLAY THE CONTAINED IMAGERY
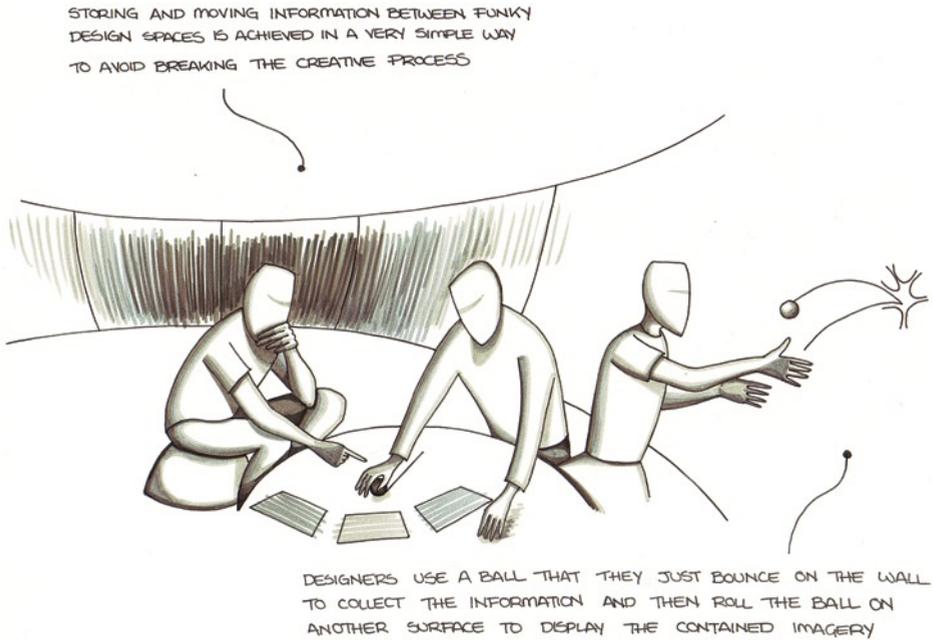
Figure 47. Interconnected funky-design-spaces

Sharing information between the different spaces is done in a simple way to support the natural creative flow.

Designers have a ball that they can bounce on a wall to collect the information and then can move to a table

and roll the ball on it to display the contained imagery

called for having freedom to go outside the design studio environment (Figure 45). Others like the *layered table* or *mood sketching* were asking for support to use the design studio space in more flexible ways so as to be able to easily display and share information on adjustable multi-purpose surfaces (Figure 46). Of course, these ideas are also the most closely related to our *funky-design-spaces* hypothesis.

The *funky-design-spaces* are set in natural surroundings (Figure 45) where designers can disconnect from the world and come back with a fresh mind. For example, designers can go into the deep woods or walk along the canal during work hours to re-energize. The dome-like shape of the environment is an open invitation to leave behind current conceptions of what a design studio is and think of new inspiring buildings that house the *funky-design-spaces*. Within this larger context, a boat on the canal or a greenhouse in the forest (section 2.3.8) could become good examples

adjustable multi-purpose surfaces

informal
relax area

communal table
for meals or
meetings

toilets

"watching the stars"

kitchen/
coffee
corner

"escape"
chair

"interconnected"

entrance
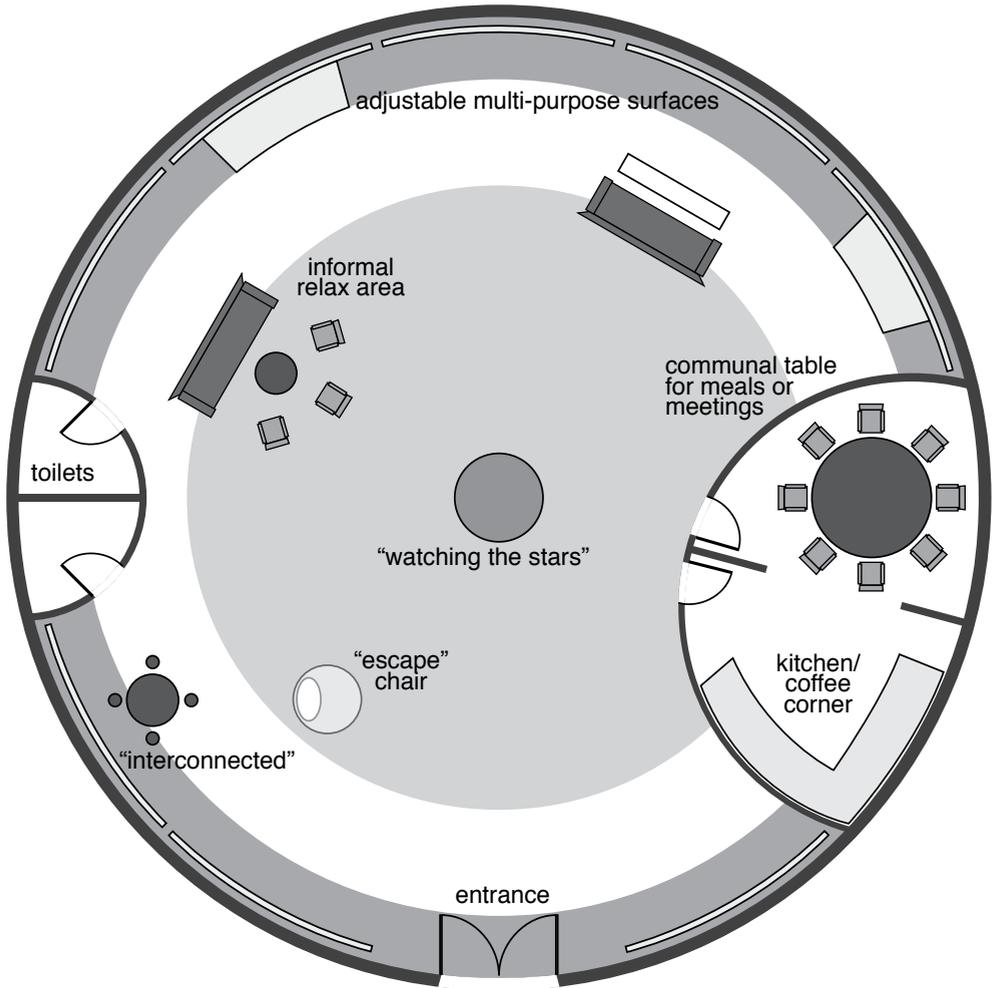
Figure 48. Floorplan funky-design-spaces

The complete funky-design-spaces vision. Special places welcome employees and visitors to create a sense of community and family. A large communal table is used for meals and meetings. Designers can take turns in cooking at the kitchen and then break bread together to share stories and enhance the feeling of belonging to a team. Several adjustable multi-purpose surfaces are available in the periphery of the studio

of design studios that house the *funky-design-spaces*. Large windows provide a direct view on the natural surroundings and allow natural light to energize designers.

Once inside (Figure 46), the *funky-design-spaces* create a relaxed and comfort-

able atmosphere where designers can engage in individual activities as well as creative collaboration. Designers feel that they belong to a larger team but they can also have a moment for themselves when needed. Adjustable multi-purpose surfaces can be used to easily display and share information. These surfaces can be assigned for different uses.

Intuitive making (activities)

The ideas contained in this group have in common that they all reflect the MB designers' need for carrying out current MB activities in ways that are more intuitive. We refer mostly to the following ideas: *tags, large cut and paste board, messy table, collecting box, collective tagging,* and *exploration wall*. All these ideas describe solutions for making current activities simpler, faster, and more accessible, while also providing an *intuitive interaction*. These ideas look at individual as well as collective exploration and creation of MBs. We have previously defined *intuitive interaction* as tools that allow designers to simply walk up to them and start performing tasks using their current skills and knowledge on the task that is being supported. There is no need to read manuals or learn new skills to master the functions provided by the tools (section 2.5.5).

Storing and moving information between these different tools or spaces should also be made in a simple way to avoid breaking the creative process (Figure 47). Designers have a ball that they can bounce on a surface (e.g. wall) to collect information that is being displayed there. Then, designers can move to any other surface (e.g. table) and then roll the ball on the surface to display the contained information (e.g. images, audio, text, etc.)

Recording encounters (process)

Two ideas, *history of the MB* and *presentation recorder*, form the final group where MB designers would like to document and share the process of making MBs. Recording the actual process of making and discussing MBs can serve as a reminder of ongoing discussions. It can also become a (audiovisual) contract between the client and the MB maker for the direction they have agreed to follow. An essential part of these ideas is to support ways of involving the client more in the MB-making process.

4.7   Discussion

4.7.1 Designers versus everyday people

In contrast to the co-design studies presented in the related work section, in our case the potential users were skilled designers, which partially reduced the need for facilitation and guidance during the dialogue. However, having designers as

co-design partners challenged our work as researchers/designers. At first designers played along with us, listening attentively and roughly doing what was asked from them. However as the session progressed, they gradually started to analyze the sessions from different perspectives and reflect on some of our decisions: *"why did you formulate this task like this?," "why did you make this separation?," "I like this material."* The setting, tasks and materials presented to the designers triggered different thoughts.

We also experienced a situation in which our participants had not recently used MBs for their work. In such cases we had to facilitate more, using our personal experiences with MBs as well as the cumulative experience from previous sessions to feed the discussion. In addition being researcher and designer simultaneously made it possible for us to grasp issues not mentioned before, and moreover bring our own ideas into the discussion for evaluation and further development. The challenge was to stay at the same level with the design partner and not push the situation or stand aside too much.

4.7.2 Motivating participants

It is the researcher/designer's role to use their own creativity to amplify the creativity of *everyday people* [Sanders 2006b]. As such, we used a layered approach to inspire and trigger people's creativity. Our strategy consisted first of reading together the instruction cards (description), and second, talking within the team (explanation). At this stage, most teams had enough information to begin working on the task. If they still needed to build a better understanding of the task, the third step consisted of playing around using the objects available on the table (the material). Having things to play with and touch helped many participants enter the fourth step that was to engage and start performing the task itself (the action). After a few minutes discussing ideas, the teams sometimes would forget the content of the task or feel they were a bit off track. In these situations, the teams naturally went back to the cards and thus restart the inspiration procedure.

4.7.3 Diversity of materials

Since different things inspire people, it is important to have diverse and flexible materials that allow a wide range of uses and expressions. Therefore, ambiguous materials such as simple geometric shapes (e.g. *make tools* [Sanders & William 2001]) that are open for many interpretations can evoke unexpected ideas. Simple models seem to open up solution space whereas more detailed models narrow it [Brandt & Grunnet 2000]. On the other hand, our notion of props getting new meanings during the sessions based on the need of the team and regardless of what established meanings they had in everyday life (e.g. postcards interpreted as material samples)

shows that it is not always the open-ended form of the prop that enables many interpretations.

4.7.4 Biases

We have previously identified two sources of possible bias in the results of the *dialogue-labs*: recency effect (section 4.4.7), and positive effect towards the researcher.

Regarding the recency effect or the cognitive bias that results from people recalling recent events better than remote ones, we were expecting the ideas that emerged from the closing discussion to have a highest mean rating. As the Playmobil® scale model was always used last, it was easier for participants to remember the details of the ideas created on it rather than those that originated in the middle of the session. In that respect, the results on the helpfulness of the Playmobil® scale model should be considered separately from the other materials that were used randomly.

Perhaps the largest source of possible bias in the *dialogue-labs* was the positive effect towards the researcher. We carefully crafted the *dialogue-labs* materials; we created a comfortable space and a relaxed atmosphere. We also facilitated and participated in the co-design sessions. The ratings given by the participants may have been biased by the *gezellig* (cozy) research context we designed. The fact that participants rated ideas (or materials) positively may not just be due to them thinking that the ideas were actually good, but also because they may have wanted to please us. Regarding this aspect, asking an independent researcher to act as the second facilitator/designer instead of the author would have avoided the bias.

4.8   Conclusions

In my quest to augment MBs with a UCD approach, instead of making my own designs based on the rich use data I collected in the activities described in the previous chapters, I decided to feed the data and results from the studies to Dutch and Finnish designers in *dialogue-labs*. We collaboratively came up with new concrete ideas for tools that support MB making with new technologies.

Our *funky-design-spaces* hypothesis was proved true by both studies. Regarding the *quality and quantity of the ideas*, the results show that participants were generally positive about the outcome of the sessions, thus the *dialogue-labs* had a positive influence on the creation of ideas. Regarding the *helpfulness of the materials*, videos and creating future scenarios with the help of a Playmobil® scale model assisted participants mostly to discuss, present, and generate new ideas. We also discovered it was important to have diverse materials and strategies to motivate participants to get started and to keep them on a creative mood throughout the session. Moreover, the experiences our participants had during the sessions show that dividing the co-design activities in physically separate tasks helps participants approach the

topic from different angles and maintain a fresh mind. In summary, researchers and designers aiming at amplifying the creativity of users should provide the conditions to support dialogue between participants, and as such, we believe our findings may inform other design processes.

AUGMENTED REALITY TOOLS

5   Augmented Reality Tools

This chapter is based on the articles:

×   *Andrés Lucero & Jean-Bernard Martens (2006) Supporting the creation of mood boards: industrial design in mixed reality. In Proceedings of TableTop 2006, IEEE, 127-128.*

×   *Andrés Lucero, Dzmitry Aliakseyeu & Jean-Bernard Martens (2007) Augmenting mood boards: Flexible and Intuitive Interaction in the Context of the Design Studio. In Proceedings of TableTop 2007, IEEE, 147 – 154.*

×   *Andrés Lucero, Dzmitry Aliakseyeu & Jean-Bernard Martens (2008) Funky Wall: presenting MBs using gesture, speech and visuals. In Proceedings of AVI '08, ACM, 425-428.*

5.1   Problem

The time spent with designers observing how they work and later in collective creation was both necessary and useful. The two-and-a-half years spent studying design practice and MB making became the foundation for letting users drive the innovation process. Now it was time to integrate the knowledge and experience gained in the previous user studies into working tools, and bring the *funky-design-spaces* hypothesis to life. However, this heavy user involvement came at a cost. I was running out of time.

The next step would have been to propose and implement a set of five interconnected tools (one for each stage of the MB-making process) that would support the creation of MBs. However, as I had decided to go for a single longer design cycle instead of several shorter ones, I realized I would have to compromise and go for an alternative plan consisting of developing two tools instead of the intended five. This would have an effect on the designers' perception of the holistic design studio that I was trying to introduce in the *funky-design-spaces* hypothesis, as the overall vision would be incomplete. The best I could aim for at this point was to allow designers to get a glimpse of the complete vision by allowing them to explore two tools working alongside each other.

I developed two tools: the Funky Coffee Table and the Funky Wall. The first one was developed before the co-design sessions and was actually shown as one of the videos with no audio for the stage *browsing* in the co-design sessions (i.e. video A). I cannot say that the idea behind the Funky Coffee Table originated in the co-design sessions. Actually, participants very quickly deviated from the original idea when we showed them the video with no sound in the co-design sessions. In that respect, the video only served as inspiration for our participants.

The second tool, the Funky Wall, was developed in between the Finnish and Dutch sessions. The tool was not shown during the co-design sessions. The video used for the stage *presenting* in the co-design sessions (i.e. video B) showed a de-

signer (i.e. me) presenting one of his MBs. Having said this, two ideas that emerged from the co-designs sessions were directly related and introduce the main arguments for the Funky Wall: *history of the MB* (section 4.4.8) and *presentation recorder* (section 4.5.8). Both the Funky Coffee Table and Funky Wall are explained in detail in this chapter.

5.2   Related work

In chapter 3, six stages of the MB making process were identified. However, later in chapter 4 we realized that expanding was not a separate stage but ran across all stages as an invitation to explore new ways of making MBs (section 4.4.7). Therefore, in our new interpretation, the process of making MBs can be divided into these five stages: 1) *collecting*, 2) *browsing*, 3) *connecting*, 4) *building*, and 5) *presenting*. Each of these stages offers opportunities for new AR designs. This related work section looks at these five stages (section 3.4.8) and how existing systems provide support for them.

5.2.1 Augmenting MBs

Collecting

First, designers who use MBs for their work are constantly *collecting* images. If they see something interesting, they collect it (Figure 49, top-left). Designers begin by roughly collecting images from large-sized magazines printed on glossy paper that they find in magazine shops and bookstores. They will also collect images from the Internet, and occasionally they will use images from their personal collection or especially make pictures for a MB.

Adding images from the Internet to a digital table can be solved through different available options (e.g. network drive, USB stick). The same holds for pictures made with a digital camera that can be sent wirelessly to the system. The Cabinet system [Keller *et al.* 2006a] (Figure 50, top-left) has addressed the issue of adding images from physical magazines onto a digital table, thus breaking the divide between physical and digital. It photographs objects placed on the workspace and replaces them with a digital footprint in the same place.

Browsing

Second, once designers feel they have enough material to work with, they will move on to the second stage, *browsing*. Here designers can spend a considerable amount of time pre-selecting images that will help them build a story or say something about the target audience, product, or company they are designing for. Designers browse magazines, cutting out pictures from them and ending up with a large number of images. Designers end up with a large pile of pre-selected images that

Figure 49. Stages of the MB making process represented through different activities

Inspiring images (top-left) – Images collected for inspiration

Piles of images (top-right) – Piles of pre-selected images that designers carry around with them

Labeling piles (bottom-left) – Piles of images are labeled using Post-it® notes

Giving a presentation (bottom-right) – A designer presenting a set of three MBs

they carry with them if they want to share its contents with colleagues for discussion (Figure 49, top-right).

We (the author and Dzmitry Aliakseyeu) explored how an AR tool can provide support for browsing images by designing, implementing and evaluating our first tool, the Funky Coffee Table.

Connecting

Third, through *connecting*, designers sort the pre-selected images in a simple and flexible way by assigning them to categories (usually up to 30 images per concept) (Figure 49, bottom-left) (section 3.4.8). MB designers will sometimes label the piles with notes. They also like the easiness of piling and arranging images within the pile. Growing piles create smaller piles and sub-piles can be mixed together in a simple way.

The creation as well as the handling of piles on digital tables has already been explored in recent systems such as Cabinet [Keller *et al.* 2006] where designers load

Figure 50. The Cabinet system and interaction with digital piles on digital tables

Cabinet (top-left) – Tool that helps designers collect and organize visual material for inspiration

Different views of piles: Drag Deck (top-right) – A closed pile (left) and an open pile ready for browsing

(right). Once opened (touch) a pile can be browsed by moving the pen maintaining contact with the surface

Different views of piles: Hover Deck (bottom-left) – Once the pile is open the user can browse its content by

hovering the pen on top of the pile. The hover direction determines the browsing direction

Different views of piles: Expand Pile (bottom- right) – The pile expands to reveal all hidden images. Left: pile

is closed with 45 images. Right: pile is expanded when the user touches the top image of the pile

images into the system and maintain workbooks of related images, with each workbook acting as a digital pile. We have also explored interaction with digital piles on digital tables [Aliakseyeu *et al.* 2006a, Aliakseyeu *et al.* 2007] identifying three basic tasks that must be supported by a digital pile (navigation, reorganization, and repositioning), and have proposed three interaction techniques that meet these requirements. In the first technique, DragDeck (Figure 50, top-right), users interact with a pile by touching the pile with the pen. Once the pile is open, the user can browse through the pile by moving the pen in a given direction while maintaining contact with the table surface. The second technique is HoverDeck (Figure 50, bottom-left) in which users open the file in a similar way to the previous technique. Then users can browse through the pile by hovering the pen on top of the pile in a given direc-

tion. In other words, the main difference with the previous techniques is that users must slightly lift the pen from the table surface to browse. Finally in ExpandPile (Figure 50, bottom-right) when users touch a pile, the entire pile expands to reveal all its contents in a similar way as the Cabinet system. Elements are scaled to fit within the workspace or the designated area for the pile.

Building

Fourth, designers start *building* the MBs by thinking how they want to cut and arrange the images, dragging them to create different layouts. Designers use different techniques to control the overall expression of the MB. For example, they will add subtle effects such as blurring by adding semi-transparent colored sheets of paper to give a more uniform feel about the color of the MB. They may also include the logo and name of the company to create a greater sense of identity with the company.

Several systems provide support to arrange images on digital tables [Jacucci *et al.* 2005, Aliakseyeu *et al.* 2006b, Keller *et al.* 2006]. Although none of these systems were originally conceived to support the creation of collages or MBs, they all provide ways to simultaneously display and arrange (e.g. move, scale, rotate) images on a digital table.

Presenting

In the final fifth stage, *presenting*, designers and clients meet face-to-face to share and discuss the intended story behind the MB (Figure 49, bottom-right). Usually designers create a single large MB or a series of smaller booklets for their clients to keep and share with other stakeholders. However, sometimes MBs stand alone embedded in a PowerPoint presentation that is uploaded to an Intranet, and designers can only hope that clients and other stakeholders perceive the intended message or story.

By co-designing, implementing and evaluating our second tool, the Funky Wall, we (the author and Dzmitry Aliakseyeu) explored how the presentation of MBs can be supported in new ways.

5.3   Approach

In the course of our user studies with Dutch and Finnish designers who create MBs for their work, we discovered that understanding the context of creation is essential when supporting the work of designers. In our vision, we see the process of making MBs going beyond the activities and the time spent by designers collecting and arranging images on a table. MB making is a dynamic and iterative process.

The *funky-design-spaces* is a vision of interconnected spaces that encourage designers to move around their design studios. Designers usually prefer brows-

Figure 51. Situations observed in our studies in relation to the Funky Coffee Table

Browsing on a couch (left) – A designer in her studio browsing images while seated on a couch by a coffee table

Desk clutter (right) – Images taking up all available space in a designer's studio including the wall behind her

ing for images away from their computer or desk, while comfortably seated on a couch, in a coffee corner or at the coffee table in a living room (e.g. when working at home). Similarly, designers present their MBs by placing them on a wall and giving an explanation in a stand up position. With this in mind, for the Funky Coffee Table and Funky Wall prototypes we have respectively decided to design the interaction on a coffee table and in front of a large wall screen to encourage *browsing* images and *presenting* MBs in a more natural setting within the design studio.

5.4   First tool: The Funky Coffee Table

5.4.1 Introduction

Browsing magazines in search for images is one of the first steps of the MB making process. Designers prefer going through their large collections of magazines in a comfortable place (Figure 51, left) where they can freely start creating *ad hoc* piles of magazines and pictures, making a soft pre-selection of images.

Designers end up with a large number of images taking up all available usable space in their design studios including tables, walls and floor (Figure 51, right). Space is not only limited to spreading images in the studio but also for storing magazines. Designers must throw away magazines in order to update their collections with new material (section 3.4.8).

Desktop and digital systems provide solutions for displaying and storing large amounts of images, however they do not provide the conditions to browse and select images in a flexible way and in comfortable spaces for designers in their design studios.

5.4.2 Related work

A considerable amount of related work has influenced the design of this tool. Most of this work is connected to image browsing, tabletop systems, and hand gesture/ movement based interaction.

A number of tabletop systems have been designed to support image browsing and sharing. Besides the aforementioned Cabinet system [Keller *et al.* 2006], the Personal Digital Historian [Shen *et al.* 2002] is a tabletop, pen-based system that helps people construct, organize, navigate and share digital collections in an interactive multi-person conversational setting. Another example of a tabletop-based system for picture sharing and browsing is SharePic [Apted *et al.* 2006], which was specifically developed for the elderly population. The main distinctive property of the system is that it is strongly influenced by the way physical photographs are handled and placed on physical tables.

There is also a considerable amount of work that addresses gesture-based interaction on tables, in open spaces, or in 3D virtual environments. Tabletop systems like Diamond Touch [Dietz & Leigh 2001], and Lumisight [Matsushita *et al.* 2004] use hand gestures and movements to interact on the table. Other authors [Wexelblat 1995, Quek *et al.* 2002, Lenman *et al.* 2002] have studied the general application of hand gestures and movements to support human-computer interaction.

The Funky Coffee table makes use of layers above the work surface which was first explored for pen-based systems by Grossman *et al.* [2006] using a single layer, and later by Subramanian *et al.* [2006] using multiple layers of interaction.

5.4.3 Designing the Funky Coffee Table

Based on the requirements we gathered from MB designers, we have decided to first provide support for the second stage of the MB making process, *browsing*, by designing the Funky Coffee Table, an image browser that: 1) merges with the real context allowing designers to work in the comfort of their existing design studio environment, 2) captures the current flexibility and intuitiveness of interaction with physical images, and 3) provides an alternative solution to a cluttered desk and messy design studio by using the space above the table to interact.

Merging with the real context: coffee table

MB designers prefer browsing images while comfortably seated on a couch, in a coffee corner or at the coffee table in a living room when working at home. Taking this into account, we have decided to design the interaction using a coffee table to encourage image search in a more relaxed environment within a design studio. Designers can sit around the coffee table and sit back comfortably on a couch.

The table had to allow designers to view at least two images to make comparisons and connections between images. Designers had told us how looking at a set of

Figure 52. Designing the Funky Coffee Table

The coffee table (left) – Long rectangular IKEA table that allows displaying three images simultaneously

Hand movements and space above the table (right) – Designers use their hands to store images in layers above the table surface

MBs makes it easier to compare the MBs in one go (section 3.5.8). Therefore, we decided to increase to 3 the number of images simultaneously displayed on the table to increase the chance and the possibilities of making new discoveries and connections between images. We used a long rectangular IKEA coffee table (120x40x40 cm.) that had the ratio needed (1:3) to comfortably display 3 images on it (Figure 52, left).

Designing interaction around a coffee table has its own implications and challenges from an ergonomic point of view. Looking at the Dreyfuss charts [Dreyfuss 1967], we realize there are aspects related to appropriate viewing angle, posture, reach, and the time people would be sitting around the table that need to be taken into account when designing interactions around such elements.

Flexibility of interaction: hand movements

From our studies we have learned that for activities involving creation designers prefer working with their hands with tools that allow for flexibility and intuitive interaction (e.g. pencil and paper). Their current way to browse, select (cut out), and create soft-piles of images is a good example of flexible and *intuitive interaction* (section 2.5.5). Inspired by this example, we decided to encourage interaction through hand movements (section 2.4.5), allowing designers to work with both hands towards achieving the goal of pre-selecting images (Figure 52, right). Designers use their hands collaboratively; each hand with a different function, as when one is using a knife and fork.

Avoiding the mess: space above the table

When designers are looking for images in magazines, they start cutting out pictures from them and end up with a large number of images. Designers will form soft-piles

of images and thus create a great amount of mess around their design studios. Piles of images and magazines will create cluttered desks and take up all available usable space in their design studios including tables, walls and floor.

In our previous studies designers have told us about the importance of messy desks as reminders for ongoing projects (section 2.3.8) and to have an overview of the available materials in one glance (section 3.4.8). Removing the mess might reduce the overview that designers now have of their work and materials. Therefore the table should also provide a simple and quick way of looking at all available materials while also partially reducing the desk clutter.

With these two aspects in mind, namely reducing desk clutter and providing an overview, we have decided to extend the available space for interacting and displaying information by using the space above the table [Subramanian *et al.* 2006]. The active area above the work-surface has been divided into multiple layers to interact with soft-piles of images, thus extending the design space (Figure 52, right). Images are stored in layers above the table (n=2), which can be easily explored to obtain an overview of the current state of the selection process.

5.4.4 Interaction techniques

We now describe how the Funky Coffee Table provides support for navigating images and interacting with soft-piles.

Browsing by flipping pages

We propose two ways to browse images based on the observations made in the previous studies as well as on the possibilities offered by AR. The first one is similar to flipping pages of a magazine in the sense that users must mimic with their dominant hand the movement anywhere above the table to switch to the next page (Figure 53, top-left). Three large-sized images (approximately A4 depending on the proportion and orientation of the individual image) are displayed simultaneously to allow designers to be captured by the atmosphere and contents of the image, hence the 1:3 ratio of the chosen table (Figure 54, top-left). The next or previous three images will be displayed depending on the direction of the movement (Figure 54, top-right). The change of pages is accompanied with a page-flipping sound.

A short and quick diagonal movement in the direction the user wants to browse defines the flipping gesture. The movement starts at the table level and goes slightly up on the z-axis, in a diagonal way. As an alternative, designers can also browse from the couch, resting their hands on the couch itself and performing the diagonal movement. The speed of the movement helps discern the flipping gesture from a free hand movement, thus preventing accidental triggering of the gesture.
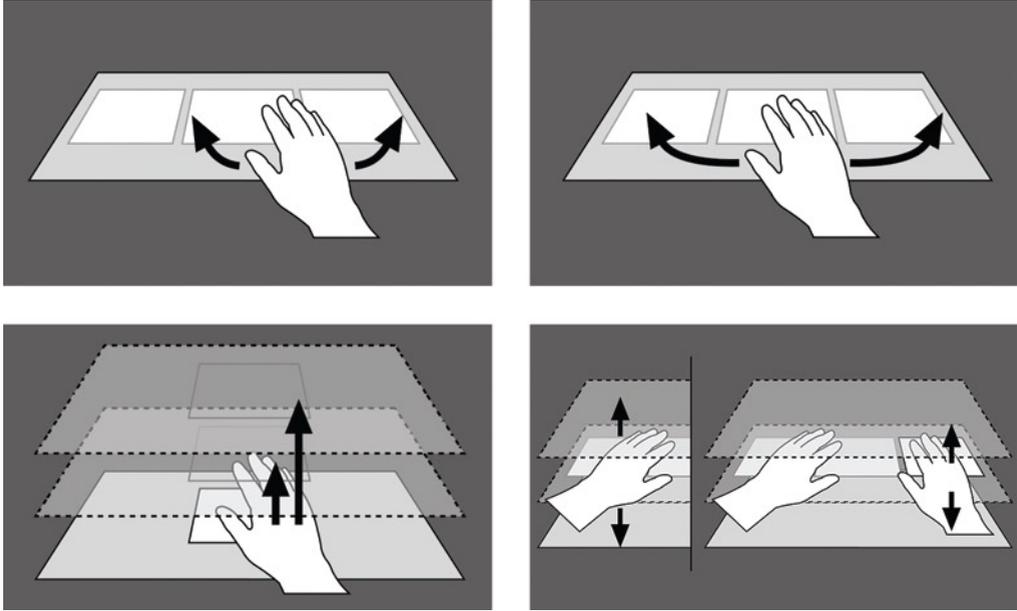
Figure 53. Interaction techniques for the Funky Coffee Table

Flipping (top-left) – Browsing by mimicking a flipping-page movement anywhere above the table

Flicking (top-right) – Browsing by doing a flicking movement on the table

Soft piles (bottom-left) – Creating soft piles by orthogonally moving a selected image

Reviewing and arranging piles (bottom-right) – Reviewing piles (left) and placing an image on another layer (right)

Browsing by flicking

Augmenting the process of making MBs implies extending the current practices by providing support using the advantages of new technologies. As such we extend image browsing by introducing techniques that pertain to the digital world.

We use a flicking movement to initiate continuous scrolling (Figure 54, second row-left). The flicking movement is similar to the flipping movement only that it is longer (Figure 53, top-right) and triggers a distinctive longer flipping-page sound. This time the length of the gesture helps us discern flicking from free hand movements. We map the direction of flicking to the scrolling direction, and the flicking speed to the rate at which the pictures scroll. The approach is similar to the one used for scrolling on the iPhone with the difference that we do not use inertia or friction, so once scrolling starts it continues with constant speed until the stop movement is performed. We decided to leave inertia or friction out to encourage designers to find their preferred continuous-browsing speed instead of having them perform the gesture several times to browse through a large collection of images. Users can stop the scrolling by tapping on the table (Figure 54, second row-right).

Soft piling

We propose the use of layers above the digital table in order to create more space to store images and create soft-piles. Once designers find an image that captures their attention, they can place the image in a soft-pile. Placing their dominant hand over an image at the table-level, and then quickly moving the hand upwards orthogonally with respect to the horizontal table surface achieve piling (Figure 53, bottom-left). The image will be placed into one of two locations at 30-50 cm. (soft-pile 'A') (Figure 54, third row-left) and 50-70 cm. (soft-pile 'B') (Figure 54, third row-right) above the table surface, depending on the highest point reached by the hand movement before it starts going down again to a resting position. The tool provides feedback for the layer by displaying a large orange 'A' or blue 'B' on the lower-right corner of the workspace.

The tool automatically scales and arranges the piled images to fit within the workspace area. The tool optimizes the space used by the images so that whenever images are removed from a large pile the images can be presented in the largest size possible (Figure 54, both images at the bottom). However, the tool also creates a clear visual differentiation between the collection and a layer. While three images are always displayed on the collection, the minimum amount of spaces for thumbnails presented on the layer is set to six. If there are less than six images on the layer, then the remaining spaces are left blank (Figure 54, bottom-left). In this way, we prevent the system from displaying three images at a collection level and three images at the layer level, which would only be differentiated by the layer feedback 'A', or 'B'.

Based on our observations of designers working with images at this stage of the MB making process (section 3.4.8), we have deliberately limited the number of soft-piles supported by the Funky Coffee Table (n=2) to meet the needs of designers.

Reviewing and arranging soft piles

Placing the non-dominant hand above the table surface and changing height accordingly allows navigating within layers of soft-piles. Placing the non-dominant hand within the range between 30-50 cm. orthogonally from the horizontal table surface results in displaying the contents of layer 'A' (Figure 54, bottom-left). Similarly, placing the non-dominant higher up on the range between 50-70 cm. will show the contents of layer 'B' (Figure 54, bottom-right).

Arranging the soft piles is achieved by using asymmetric two-handed interaction. First users must choose an image using the non-dominant hand to reveal the layer contents of either layer 'A' or 'B', and then place the dominant hand on top of the image at the same orthogonal height as the non-dominant hand to activate it. The tool provides feedback by dynamically enlarging the active image by 20%. Second, while still keeping the non-dominant hand at the current layer location and then placing the dominant hand at a desired new location (Figure 53, bottom-right)
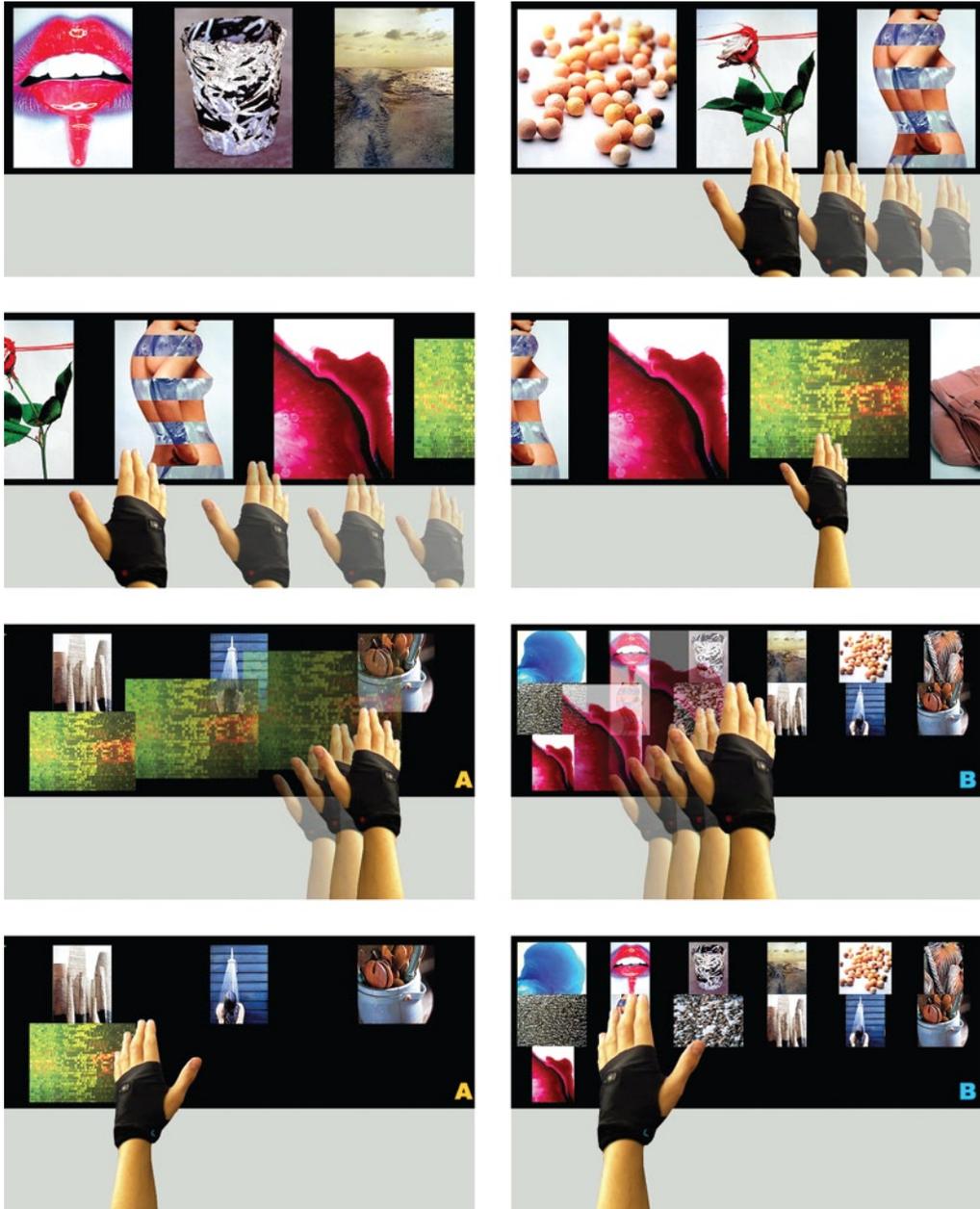
Figure 54. The Funky Coffee Table tool

Start (top-left) – The three first images of the collection are shown in a large size

Flipping (top-right) – The next or previous three images are displayed after the flipping gesture is performed

Flicking (second row-left) – A similar but longer movement triggers a continuous scrolling

Stopping flicking (second row-right) – Tapping on the table stops the continuous scrolling

Piling to layer A (third row-left) – Piling the green central image to layer A by performing an orthogonal move-

achieve removal of an image from a soft-pile or positioning an image to another soft-pile. In this way, we are making the interaction simpler by having designers use both hands collaboratively where one hand has a different function from the other.

5.4.5 Evaluation

The usability and usefulness of the Funky Coffee Table prototype were tested in an exploratory user study. One of the main questions that we wanted to answer was: will practicing designers see the prototype as a relevant tool for creating MBs? Moreover we wanted to test the interaction techniques (hand movements) in terms of naturalness, ease of learning and use. The evaluation was conducted with 10 practicing designers with at least 5 years of experience (13 years of experience on average). The participants varied in their education (university/academy), age (between 30 and 46), gender (7 male, 3 female), and dominant hand (8 right, 2 left). The evaluations were conducted individually. All sessions were recorded on video.

Implementation

A tabletop tool was set up using a desktop PC, which controlled a top-down projector projecting an image of size 120x40 cm (1272x424 pixels) on a white IKEA table (120x40x40cm) (Figure 55, bottom-right), as well as an ultrasonic tracking system – InterSense IS-600 used to track hands. Participants sat on a couch next to the table. The application was written in C# and OpenGL was used for visualization purposes.

During the sessions participants wore custom-designed interactive gloves that contained the sensors for the IS-600 tracking system (Figure 55, top-right). The gloves were made in Lycra (Figure 55, bottom-left) to allow a comfortable fit for different sizes of hands and were hand sewn.

Designing and making the gloves proved to be much more challenging than anticipated. It took us 4 weeks to come up with a final design. The created design had to be both durable and easy to disassemble so the batteries can be replaced.

In the end, four pairs of gloves from different materials were designed and tested with the sensors in them before the final design was ready (Figure 55, top-left). As a finishing touch, a blue 'L' and a red 'R' were embroidered on the left and right gloves respectively.

ment with respect to the horizontal table surface and stopping between 30-50 cm from the table

Piling to layer B (third row-right) – Piling the fuchsia image to layer B by stopping the orthogonal movement between 50-70 cm. from the table

Reviewing layer A (bottom-left) – Reviewing layer contents using the non-dominant hand

Reviewing layer B (bottom-right) – Reviewing layer B by placing the non-dominant hand higher

Figure 55. Design of the interactive gloves and experiment setup

Early designs (top-left) – Four pairs of gloves were designed and tested

Sensor and battery (top-right) – Location of the sensor and battery cradle inside the glove

Final design (bottom-left) – Final interactive gloves with 'L' and 'R' for left and right hand respectively

Experiment setup (bottom-right) – Experiment setup with the coffee table, gloves and couch

Tasks

Users were asked to focus on both the relevance of the application for the creation of MBs, and on the interaction techniques. Following a description of the interaction (approximately 5 minutes), participants were allowed to freely explore the functionality and get acquainted with the application (approximately 5 minutes).

Participants were later asked to perform simple tasks (i.e. change pages, start and stop scrolling, create piles, re-arrange a pile), starting with 30 different images at the table-level. Finally, a short post interview was conducted. The average time per participant was 30 minutes.

5.4.6 Findings

General principles

In the first part of our exploratory evaluations, designers started trying out the interaction techniques and as a general observation we can say that they were all able to use the tool with little or no prior training. They especially liked the naturalness

and simplicity of the interaction and of the overall tool as can be observed from the following reactions:

× *"I think the movements that you have to make in order to browse are very natural. It really looks like you are actually browsing a magazine." [P1]*

× *"It's beautiful! It's very nice; it's a very nice interaction. (It is) what I intuitively do when I am just organizing stuff, I have piles around me, I put some things here and some things there." [P2]*

× *"I like the flipping movement a lot, it is very quick and clear in combination with the sound." [P5]*

× *"(The proposed interaction) is a more natural way of browsing and you can work in different layers at the same time, so you don't need to do an extra movement that is not related to your actions in order to change the layer. That's what happens now with a 2D browsing system. So you can browse and change layers at the same time. The multitasking I guess is interesting, not because you are going to do all the things at the same time, but there could be some overlap between things. This small overlap between things is nice." [P6]*

× *"On one hand I like the idea that you have some kind of repertoire on gestures. This is a wonderful poetical view. It's very pure and it's very playful for mastering the whole process (of working) with a lot of images and when in your head you always know where things are. So you can store things in layers which I think is interesting." [P3]*

× *"It feels like browsing through stock images or digital images, but the bigger ones that I am used to with analogue material from magazines. So I like that the image is being projected (large), colorfully, and bright, and that I can even browse through them. That, I like. Then I like that you can control the speed." [P8]*

× *"There's enough logic to it in browsing layers and moving images between layers. And that is something that amazes me because it's kept simple, in two layers, but you already use a 3 dimensional virtual idea, while still having a 2 dimensional (surface) that I have to congratulate you on. It's beautiful! That really changes the way you think about interface, that you have in fact virtual possibilities in your own mind." [P10]*

Hand gestures

Regarding the interaction techniques, we observed that flicking initially caused most difficulty to our participants, followed by piling. It took two attempts to get flicking going for five participants while one participant needed three tries to get piling working. In the first case, the attempt to do a flicking movement would result instead in flipping a page due to the fact that only the length of the movement differentiates both movements. After these initial difficulties participants were able to continue with the interaction.

There was one conceptual interaction problem for 6 participants who were trying to rearrange a pile by moving an image from the middle layer to another layer. All 10 participants were able to access the middle layer with their non-dominant hand but upon displaying the layer on the table, they tried to interact with the elements using their dominant hand at a table-level instead of at a middle layer-level. They all overcame the problem upon further exploration indicating, *"It works fine once you know what to do."*

Four participants expressed concern about fatigue:

×   *"I am a bit concerned about how much time I have to hold my [left] hand in the air, however, the principle behind it is quite logical…" [P1]*

×   *"(Doing the flicking movement repetitively) can be quite tiring for me…" [P5]*

×   *"To be able to work at a layer level I have to hold my hand in that position. And already within a few minutes I could feel it in my arm. So that is not comfortable. I think you can solve that if you just select the level (layer) with your left hand but so that it stays there (on that layer)." [P8]*

×   *"Keeping your hand in midair, especially if it doesn't work like you wanted it, then you have to keep you hand extended in midair for one and a half minutes. We're not built for that I'm afraid." [P9]*

Regarding the relevance of the proposed application, all participants saw a practical use of the image browser in their design studios. They liked the fact that they could dynamically browse images (flicking) to make connections with images:

×   *"This kind of browsing gives you more opportunities to select images." [P1]*

×   *"I like the fact that images just come by (flicking). I could imagine that there's even more than just horizontal (scrolling). So horizontally, this is a group of images or a magazine, and then you can also browse vertically and then you go through different groups of magazines. That would be nice (to) give you the feeling of (making) a pre-selection." [P10]*

Feedback

Regarding the feedback provided by the tool, participants mentioned two main aspects: the naming of the selected layer (i.e. 'A' or 'B'), and the feedback for the selected image within a layer. With regards to the former, participants said:

×   *"I think the naming of the layer should be done differently. Maybe with gestures indicating the number of the layer with your fingers. Then you don't need to have the feedback on the table with letters because in a way you are still using the principles of GUIs (graphical user interfaces), and now with gesturing you have all the possibilities so don't go back to labeling things." [P6]*

×   *"The letter for the layer 'A' or 'B' is very much in the outer corner of my awareness. 'A' and 'B' is also not very poetical. In a certain way this table is poetic with this transformation or interpretation of gestures (hand movements) into actions. So I*

could also imagine displaying A and B by a filling-up column or a color or something like that." [P3]

× "The fact that there are two different colors for the layer letter is good. It's interesting that it's in the corner, it doesn't take up space and still you know that something is changing there in the corner of my eye. But I can imagine it could also be (represented as) a colored dot. Nevertheless I would keep the 'A' and the 'B' because it's easier to talk about." [P10]

The second aspect mentioned by participants was connected to the feedback provided by the tool by enlarging a selected image when it becomes active within a layer:

× "I guess it's enough to show the selected image by enlarging." [P6]

× "The feedback for the image that is selected during piling, you would also expect it at the table level when you begin piling. You can't miss which image you're trying to pile but to be consistent you would expect the same enlargement." [P9]

Interaction above the table

We asked participants about setting the interaction above the table by extending the available space using layers. Participants agreed with the idea of using the active work-area above the table:

× "I think it's a nice idea to use the space above the table because then you have everything above the same area (table), so that you don't have to pick up the images from the floor next to the couch. That's what actually happens now, that you end up with photos everywhere." [P6]

× "I find it useful because it has a physical layering, but I don't find it useful to work so that it forces you to keep your hand in the air." [P8]

× "I think it's a good thing. I think it works really well." [P7]

× "My fist indication is that I really love it. Browsing is beautiful. But I could imagine that some people could handle more layers. So the number of layers could be adjustable depending on what you are doing." [P10]

Future uses

Regarding future applications of this table, some participants speculated over possible uses of the table:

× "It looks very promising. You could create an application in combination with the Microsoft table (Surface)." [P1]

× "I think that for the household, you have a digital camera with photographs from your family, children and then you can select the pictures to print out." [P3]

× "I know that the Japanese order at the McDonalds like this. They project the meals on the table. This table makes me feel much more like the iPod or iTunes that you browse through the collection of music, books, things like that." [P9]

×   *"This table compared to my computer screen and all the thumbnails on it that are enlarged to the screen size, is so much more beautiful. And then you also have the three layers where I can imagine the client saying 'can we go back to layer B?' This could be a very compact editorial table." [P10]*

5.4.7 Discussion

Appropriateness of the (coffee) table

We believe that the choice of the IKEA table (and couch) has affected how designers perceived the prototype in a positive way. Designers realized that this was not a standard coffee table, but a modern and sleek one that could perfectly be found in a design studio. As such, the chosen coffee table helped greatly in addressing the importance of the context of creation.

Regarding how the interaction is affected by the seating position around the coffee table, the tool currently allows browsing and piling images while designers are sitting comfortably and resting their back. However, for re-arranging piles, designers must lean forward to view the images that are in piles (due to their smaller size), and to interact with them. We predict that designers will spend a considerably larger amount of time browsing images than re-arranging them so our main concern at this point is what would happen with the perception of the tool over prolonged use.

Interaction based on hand movements

In our prototype we have used one-point ultrasonic tracking (ISense). Alternative solutions such as vision-based tracking can potentially support a richer set of movements and can also add hand gestures, however, as was pointed out above, the main motivation for choosing hand movements to interact was to keep interaction as light and simple as possible. In this respect the tracking capabilities of the ISense were enough for recognizing a small set of movements implemented in the prototype. In relation to a design-studio context, video-based recognition will probably be more appropriate due to smaller size and price.

Designers favored not having additional interaction devices (i.e. holding tangible objects). The gloves were comfortable and unobtrusive and were perceived as a means to track hands and not as an interaction device.

Virtual space above vs. around the table

Some participants suggested a few gestures that could be implemented in the prototype to also support interaction around the table (i.e. at a table-height level, adjacent to the table). We initially considered this option for our prototype especially because it fits the selection process: *"I choose this image, so I bring it towards me."* However we believe this type of interaction mimics what happens on a normal

desk but does not support the ergonomics of seating on a couch. On a normal desk, people sit (or stand) at a different height with respect to the table, and can rest their elbows on the table. Their reaching possibilities are fundamentally different than when seated on a couch. The vertical space above the table becomes then easier to reach than the space around it.

Having said this, setting the interaction above the table did introduce conceptual difficulties for interaction as far as the mental model from the users and the one we were trying to introduce. When re-arranging a pile, the action space is set in midair (i.e. holding both hands above the table to access a layer and interact with an image), while the perception space is located at table-level (i.e. image projected on the table). Participants instinctively tried to grab the projected image at table-level instead of layer-level.

One possible solution for this problem could be to use the concept of marking menus [Kurtenbach & Buxton 1993], where different actions can be assigned to the eight points of the compass or cardinal (i.e. North, East, South, and West) and ordinal (i.e. Northeast, Southeast, Southwest, and Northwest) directions. In such a case, left and right would be used to browse images forward and backwards as it is now, and other directions can be assigned to put images in piles. For novice users, pressing and waiting would display a discoverable menu as a reminder of the different options available. An expert user would simply perform the gesture in the given direction. These eight directions fall within the capacity of short-term memory and therefore can be remembered and learned very quickly. The actions can be performed almost automatically with eyes closed so that the attention is always on the work.

Interaction on vs. above the table

During the evaluation we observed that users had no problems with staying in one layer or moving between layers, however they all had some difficulties arranging piles. While the movement itself was well understood most users needed a few attempts to perform it.

All hand movements including page flipping could be performed in midair (it was not necessary to touch the table surface), however all participants used the table surface to start a hand movement and generally had less errors performing this hand movement than when performed in the air. This indicates that interaction in mid air should be kept for simple actions while interaction on the surface can be more complex (this also is inline with findings reported by Subramanian *et al.* [2006]).

We observed that setting the interaction in an unstable position where users are unable to rest their hands not only causes fatigue but also generates imprecision in the interaction (e.g. staying within a layer with the non-dominant hand).

Number of piles

We defined the number of piles (n=2) for two reasons. First, our studies showed that when designers start searching images for MBs, they create a few soft-piles (1-3) containing around 20 images each. Second, to keep the interaction above the table comfortable, we set the distance between the first layer (table surface) and the second layer at 30 cm, and the distance between the second and the third at 20 cm. Adding more layers would imply either placing layers on top in an area that is difficult to reach while sitting on a couch, or reducing the distance between layers, adding extra restrictions to the set of hand movements. We are also relying on the acuity of motor memory for the number of layers above the table that people can work with. We believe it would be difficult for people to keep track of more than four layers.

5.4.8 Conclusions

We introduced the first of two prototypes providing support for the MB making process. The Funky Coffee Table is an interactive tabletop tool that supports image browsing as one part of the process of making MBs. The tool addresses the importance of the context of creation (section 2.5.6) by setting the interaction around a coffee table for designers in the context of their design studios. The tool also follows the principles of *intuitive interaction* (section 2.5.5) by encouraging designers to interact with the tool by means of hand movements (section 2.4.5) or asymmetric two-handed interaction. Finally, the tool extends the available workspace to store images by interacting and displaying information in the area above the table. Piles of images can be created in two layers above the table.

Through a user study we explored the limitations of the tool in terms of placing the interaction above the table, the proposed hand movements, and the image browser itself. As a general remark, the evaluations showed that designers were able to use the tool with little or no prior training, and to see a practical use of the proposed Funky Coffee Table in their design studios. Regarding the hand movements, participants were positive on the naturalness and simplicity of interaction with the tool. However, they did show some concerns about fatigue in terms of how much time they would be able to use the tool, especially if they are required to keep their hands in midair to re-arrange piles. Finally, setting the interaction above the table introduced some discrepancies with regards to the users' mental model, especially when the action-perception spaces are not matching (i.e. re-arranging piles).

The ideas for the Funky Coffee Table were not generated in the *dialogue-labs* (chapter 4), but instead were based on findings from the contextual inquiries and MB interviews (chapter 3). Therefore, we wanted the second tool to reflect some of the ideas that emerged during the co-design sessions.

Figure 56. Situations observed in our studies in relation to the Funky Wall

Giving a presentation (left) – Designers guide clients through the presentation by means of an explanation

PowerPoint presentation (right) – A MB embedded in a PowerPoint presentation

5.5   Second tool: The Funky Wall

5.5.1 Introduction

After designers have gone through the complete process of *collecting, browsing,* and *connecting* images, and then actually *building* the MB, designers also have to present the result of their work. They must communicate the story (and the ideas) behind the MB to their clients. Presentation and communication become important aspects to make sure that the right message is conveyed. Clients are guided by means of an explanation given by the designer so they can understand the ideas behind the MB (Figure 56, left). However, it is also important how clients perceive the MB. Receiving feedback and having a constructive discussion is what MBs are all about: they support idea development by making both the client and the design team think and reflect on the different possibilities for a future product, service, or trend.

Usually designers will have meetings with their clients to present, discuss and receive feedback on their MBs. However, in large companies MBs are created as inspiration for designers, and other departments within the company (e.g. marketing, sales, advertising). These MBs set the atmosphere that will later define the direction for design. These MBs are made available on the company's Intranet for different departments to look at and experience them.

It is also common that clients and the design team itself are distributed over the globe, working in different time zones. MBs are then embedded in PowerPoint presentations (Figure 56, right) and an extra A4 text document is attached with an explanation of the MBs. In these cases, Intranet or PowerPoint presentation (section 3.5.8), the main question is, how can designers make sure that the right message is conveyed? Why was a given image chosen? What is the path through the MB that

the designer intended in order to tell the story? And equally important, how can clients reply and give feedback on what they are thinking? More generally speaking, how can we support *presenting* and receiving feedback for a MB?

5.5.2 Related work

Gesture and speech-based systems

Clark and Brenan [1991] and McNeil [2005] have extensively studied the relation between gestures and speech, and the role of gestures in human communication. Clark and Brenan argue that gestures together with communicative statements help establish common understanding, and that an appropriate gesture that is easily interpretable is preferable over complex sentence constructions.

Gestures have also been widely explored as a natural way of interaction for a range of systems such as tabletop systems, vertical displays, multi-device environments, and 3D virtual environments [Baudel & Beaudouin-Lafon 1993, Bekker *et al.* 1995, von Hardenberg & Bérard 2001, Vogel & Balakrishnan 2004]. Several projects have studied the application of hand gestures and movements to support human-computer interaction. Bekker *et al.* [1995] looked at gestures that people use when engaged in design activities and, classified them into 4 groups: kinetic, spatial, pointing and others. They made two interesting observations that are relevant to this work: they observed that gestures are carefully synchronized with speech and that gestures occur in relation to the spatial organization of participants and work artifacts [Bekker *et al.* 1995]. This is in line with the work of McNeil [2005] who argues that gestures are an integral component of language. Hardenberg & Bérard [2001] studied the usability of bare-hand human computer interaction. The study focused on using static hand postures for issuing a command, and fingers for pointing. They also proposed a number of application areas, one of which is a wall projection system. From the user's perspective, the complete system consists of an interface projected on the wall. The study demonstrated that the proposed prototypes could indeed be controlled using hands-only interaction [von Hardenberg & Bérard 2001].

An example of a public display system that is controlled by gestures was presented in [Vogel & Balakrishnan 2004]. The authors aimed at studying shared, interactive public displays that support transition from implicit to explicit interaction. They used hand gestures and touch for explicit interaction, while body orientation and location played part in implicit interaction. They also proposed four interaction phases that are based on the distance between the user and the display: ambient display (furthest distance), implicit interaction, subtle interaction and personal interaction (closest distance).

A few systems employed gesture-based interaction in addition to speech, for either enriching the presentation process or to improve the communication with

remote parties [Tang & Minneman 1991, Baudel & Beaudouin-Lafon 1993, Tang *et al.* 2004]. The Charade system [Baudel & Beaudouin-Lafon 1993] allows presenters to use free-hand gestures to control a remote computer display, while also using gestures for communicating with the audience. Tivoli [Pedersen *et al.* 1993], an electronic whiteboard, is another example of a system where a free-form gesture based interface was employed to enrich presentations and discussions during meetings. VideoWhiteboard (VideoDraw) [Tang & Minneman 1991] enables remote collaborators to work together much as if they were sharing a whiteboard. The key aspect of the system is that collaborators not only see drawings but also the shadows of the gestures made by the collaborator at the remote site. The authors argue that the gestures' shadows provide a stronger sense of co-presence. Another system that employs gesture shadows is Mixed Presence Groupware [Tang *et al.* 2004]. Kirk *et al.* [2006] studied different ways to represent gesture shadows (hands, hands and sketch, sketch only). They concluded that unmediated video representations of hands speed up performance without affecting accuracy.

Most of the previously presented research looks at real-time communication, where collaborators interact in real time (they can be either physically co-located or in different locations). It is, however, unclear to what extent their research findings can be applied in a situation where communication does not happen in real time but rather offline.

Capturing and browsing meeting content

There is a large area of research that looks at optimal meeting content capturing and browsing [Geyer *et al.* 2005]. Many of these systems are based on the idea of Activity-based Information Retrieval, which proposes to use user activity (such as note-taking, annotating, writing on whiteboards) to index multimedia data and make data retrieval easier [Lamming 1991]. The main difference with our tool is that most of these systems only look at speech and handwriting notes and not at hand gestures, as means to segment the meeting and to identify bookmarks [Chiu *et al.* 1999, Geyer *et al.* 2005]. The Cornell Lecture Browser [Mukhopadhyay & Smith 1999] uses video and speech analysis to capture a structured environment (a university lecture) using only passive capture and segmentation (no explicit actions are required from the presenter).

Only a few examples can be found where a speech plus gesture approach is used to enrich the capturing and (re)viewing of presentations. Ju *et al.* [1997] use a motion estimation technique to detect key frames and segment the video (recorded presentation). The proposed method is robust with respect to slide motions, occlusions and gestures. In addition it enriches the slides by indicating where the speaker is pointing. Another example is the Active Multimodal Presentations [Elsayed 2006] concept.

Most of these systems include both explicit and implicit information capture and segmentation. The Funky Wall, however, attempts to create a structure using only implicit information. Plus it uses gestures and segmentation (together with speech and vision) as an additional information channel (that is presented to the viewer through gesture traces).

5.5.3 Designing the Funky Wall

After providing support for browsing with the Funky Coffee Table, and based on the ideas that emerged during the co-design sessions (i.e. *history of the MB* and *presentation recorder*), we decided to also design support for the final part of the MB making process, *presenting*, by designing a Funky Wall that: 1) allows designers to easily record their MB presentations while capturing the richness of their individual presentation skills and style, 2) allows both designers and clients to play back and explore different aspects of the presentation using an intuitive and flexible interaction involving hand movements and body position (i.e. proximity), and 3) supports two-way communication needed for successful MB design, by allowing clients to reply and share their thoughts on the MB contents provided both sides own the same tool.

Proximity-based interaction

The Funky Wall employs four different ranges of interaction depending on the designer's proximity to the MB: showing, contemplating, replaying, and exploring.

Different interaction modalities and functionalities are made available to the users (i.e. designers or clients) based on the distance from the screen. Gesturing close to the screen is used to record a presentation or comment on an existing presentation (less than 0.5 meters). When the presentation has been created, designers or clients can then contemplate the MB from a distance (more than 2 meters, no gestures), they can replay the entire presentation (gesturing between 1.5 and 2 meters), or they can also explore specific parts of the recorded presentation (gesturing between 0.5 and 1.5 meters). Our four ranges of interaction resemble the ranges proposed by Vogel & Balakrishnan [2004] and in Hello.Wall [Prante *et al.* 2003].

Intuitive and flexible: hand movements and speech

As previously mentioned for the Funky Coffee Table (section 5.4.3), we have decided to follow the principles of *intuitive interaction* (section 2.5.5) by encouraging designers to interact with the tool by means of hand movements (section 2.4.5). To keep the interaction simple, designers can record their presentation by gesturing and explaining the MB in front of the screen, using their hands to point or outline specific areas of the MB as they would do in case of an actual presentation.

When a presentation is given, the tool automatically records and keeps essential

aspects of the presentation at three main information layers and in combination with the MB itself: gesture, sound (speech) and vision. These information layers are analyzed in order to split the presentation into a number of meaningful segments. Each segment is associated with a specific time, interval and specific area on the MB (not every segment has this property since part of the presentation can cover general aspects of the MB without relating to any specific part). There are three important attributes that are used for splitting: the location of hands, the acceleration of gestures, and pauses in speech. Preliminary observations show that location and speed of the gesture can be used as means to create meaningful indices, i.e., to associate the speech layer with a particular area of interest. These attributes allow segmenting the audio file and associating every segment with a specific area in the MB.

Two-way communication

A MB is an idea development tool. During the MB making process, designers and clients have several rounds of discussions to reach agreement on the ideas being presented in the MB. Therefore, for a successful MB design the tool should support two-way communication between designer and client. The Funky Wall supports this iterative process by allowing designers and clients to provide input by creating a presentation and share their thoughts by providing feedback. For this type of communication to happen, two Funky Walls are needed, one for the designer and another for the client.

5.5.4 Interaction techniques

Showing

To begin recording their presentation, designers simply need to gesture and speak in front of the MB at close range (less than 0.5 meters from the screen) (Figure 57, top-left). As designers are using both hands to gesture in front of the screen, the tool displays white traces of the gestures made, as if designers were putting down a continuous flow of paint with their hands (Figure 58, top-left). To allow good visibility of the MB the opacity of the white trace is set to 30%. Additionally, ten seconds after the gesture has been overlaid on top of the MB it gracefully fades out to 25% opacity. In this way, the latest traces left by the designer are made more prominent than previous ones.

The tool captures and segments both the speech and the natural hand movements made by the designer, hence creating associations between audio segments and gestures. Wang Freestyle (Levine & Ehrlich 1995) is a system that allows users to annotate a document (TIF file) using a stylus, and speak while they are annotating. The file is then emailed back to the intended recipient who can play back the audio synchronized with the marks made.
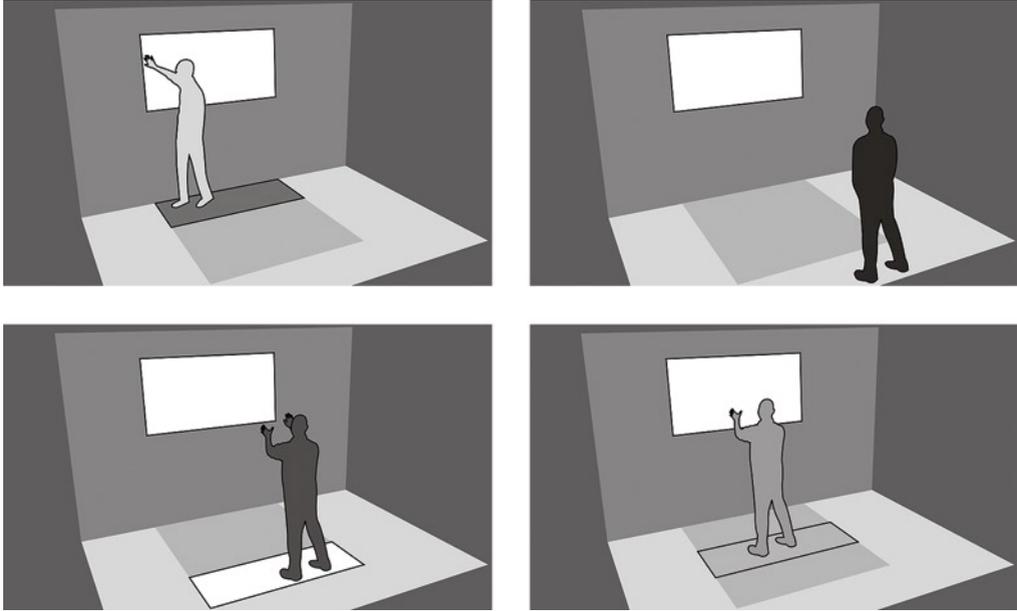
Figure 57. Proximity-based interaction. Different parts of the tool are revealed depending on the designer's proximity to the screen.

Showing (top-left) – Showing by gesturing next to the screen (<0.5m)

Contemplating (top-right) – Contemplating the MB from a distance for a comfortable overview (no gestures >2m)

Replaying (bottom-left) – Rising the dominant and non-dominant hands display all gestures and the complete audio explanation respectively (gesturing 1.5-2m)

Exploring (bottom-right) – Exploring specific parts of the presentation. The dominant hand displays the dynamic visual gestures while the non-dominant hand triggers the associated audio (gesturing 0.5-1.5m)

Contemplating

Once a presentation has been completed, the spectators (i.e. designers or clients) can review the recorded presentation (Figure 57, top-right). Users contemplate the MB from a distance greater than 2 meters. This allows spectators to have a more comfortable and clean overview of the MB. No gesturing is possible at this range (Figure 58, top-right).

Replaying

Spectators can replay the entire presentation by approaching the screen at a distance between 1.5 and 2 meters from the screen (Figure 57, bottom-left). At this range, users can have an overview of the associated recorded content created by the
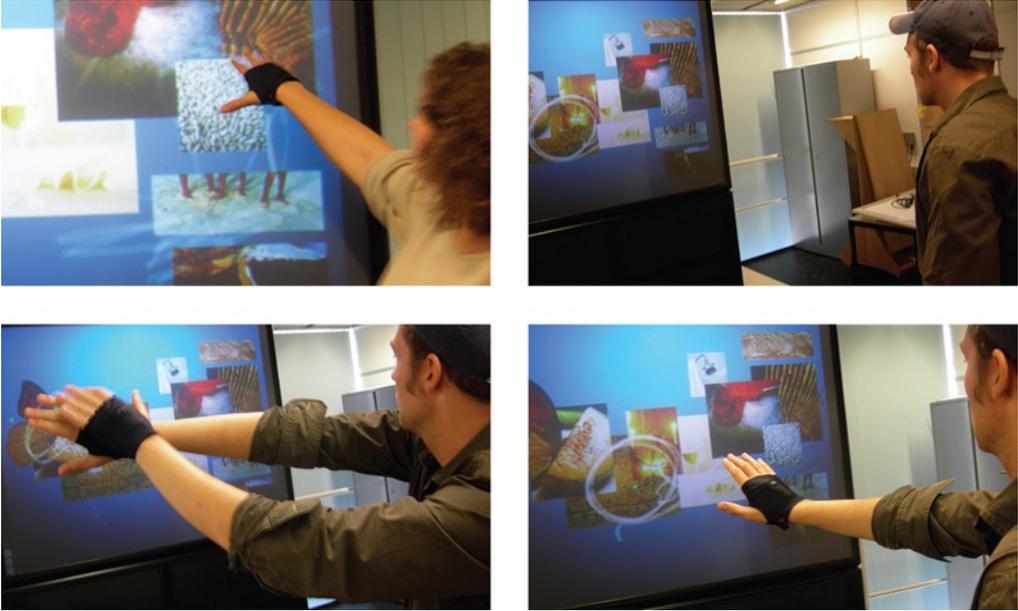
Figure 58. Proximity-based interaction. Designers interacting with the four main parts of the tool.

Showing (top-left) – White traces of the gestures made by the designer are displayed

Contemplating (top-right) – Having a comfortable and clean overview

Replaying (bottom-left) – Putting both hands together triggers both the recorded speech and the transparent dynamic gestures

Exploring (bottom-right) – Viewing a static representation of the gestures made in a specific area by pointing with the dominant hand.

designer while showing the MB, and which the tool recorded. Raising the dominant hand results in displaying a static representation of all gestures made during the presentation semitransparent on top of the MB (Figure 59, top-left). Raising the non-dominant hand will trigger the complete speech or audio explanation. By putting both hands together, the recorded speech will be played and the transparent dynamic gestures will unfold as the presentation progresses (Figure 58, bottom-left).

Having an overview of all gestures by displaying them as a static representation allows spectators to quickly see areas of high interest where gestures concentrate. This might be helpful for example if the spectator wonders whether or not the designer has addressed specific parts during the presentation.
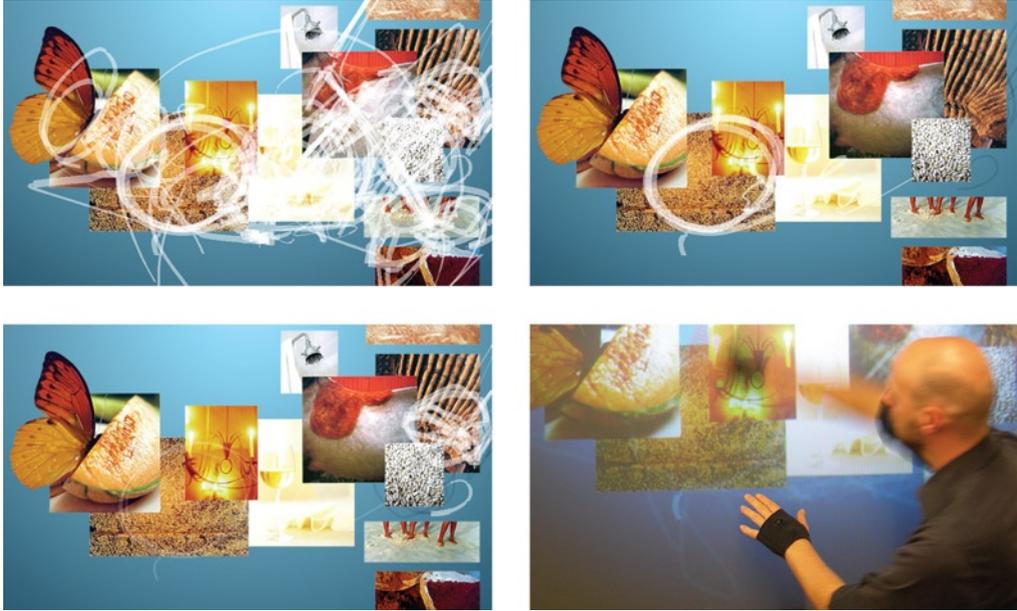
Figure 59. The Funky Wall tool

Replaying (top-left) – Visual feedback displaying all gestures made during the presentation semitransparent on top of the MB

Exploring (top-right) – Static representation of the traces made on top of the image (textured wall)

Visual contextual feedback (bottom-left) – The tool highlights the currently selected gesture in white (wood), the previously selected gesture in a lighter shade of white (textured wall), and the next gesture in black (beans)

Experiment setup (bottom-right) – A designer exploring specific parts of the presentation wearing the interaction gloves

Exploring

If spectators want to explore specific parts of the MB, they can take one step closer towards the screen (between 0.5 and 1.5 meters) (Figure 57, bottom-right). By pointing with the dominant hand to a given area in the MB, users can view a static representation of the traces made in that area (Figure 58, bottom-right & Figure 59, top-right) while the rest of the traces remain hidden. These overlaid traces of gestures serve as guides for retrieval. We provide visual contextual feedback so that spectators are able to identify time-based connections between associated explanations (i.e. gesture and speech) within the presentation. The tool highlights both the explanations made by the designer just before and immediately after the currently selected gesture. The currently selected gesture is displayed in white, while the

previous gesture is shown in a lighter shade of white as if faded. The next gesture is displayed in black, as something that still needs to be discovered (Figure 59, bottom-left).

Putting both hands together display the dynamic gestures together with the corresponding spoken explanation. The tool allows the entire MB to remain visible while individual areas are highlighted, and gesture trails are triggered.

If after reviewing the presentation the designer is unsatisfied with the results, they can go back and make the presentation once again by following the procedure described for showing. The assumption here is that MB presentations usually last somewhere between 5 and 8 minutes. Therefore, instead of providing a tool that allows editing specific parts of the presentation, we propose that they make the entire presentation over.

Supporting two-way communication

When designers are satisfied with the recorded presentation, they can share it with their clients who are located at a remote location. By having a similar Funky Wall in their offices, the clients can hear and see the associated explanation or story that the designer originally wanted to convey. The clients can explore the entire presentation or specific parts of it by following the procedures described in contemplating, replaying, and exploring. But more importantly, to truly support two-way communication, clients must be able to give designers feedback based on their perception and interpretation of the MB.

Clients can reply and add their own comments to the MB using the same interaction modality used by designers to record their presentations described in showing (gesturing at less than 0.5 meters from the screen). In this way, designer and client can have several iterations throughout the MB making process.

5.5.5 Evaluation

We conducted exploratory user evaluations of our prototype in order to test the usefulness and usability of the Funky Wall (Figure 54, bottom-right). First, we wanted to see if practicing designers would see the prototype as a relevant tool to present their MBs. Second, we wanted to test the interaction techniques in terms of naturalness, ease of learning and use.

We recruited 12 practicing designers with at least 5 years of experience in design practice (13 years of experience on average). The participants varied in their education (university/academy), age (between 30 and 46), gender (9 male, 3 male), and dominant hand (10 right, 2 left). The evaluations were conducted individually. All sessions were recorded on video.

Tasks

In the first part of the study, we asked participants to present a MB to us using our tool. We asked them to bring a MB they had created for a past project. If they were unable to bring a MB with them to the session, as an alternative we showed them one of our own MBs and we let them create their own story around it. Each participant was told that during their presentation, they would be using a tool that tracked their hand movements and record their speech, while the tool would display traces of their hand movements. This part lasted for approximately 5 minutes.

In the second part of the study we asked them to play the role of the client by letting them discover the story behind a MB that was provided to them. Each participant explored a presentation we had prepared in advance using the tool. Following a brief description of the interaction we allowed them to freely explore the functionality and get acquainted with the application. This part took approximately 10 minutes.

In the third part of the study, we asked them to walk us through their experiences while creating their own presentation and then while exploring the given presentation. They shared their thoughts on their interpretation of the different stages of the interaction and the feedback provided. In this final discussion, we wanted to assess the relevance of our tool for presenting MBs to their clients. We also tried to see if they were able to perform the hand gestures. This discussion lasted for 30 minutes, on average per participant.

Implementation

A tool was set up using a desktop PC connected to a back-projection screen with resolution 1024x768 pixels and physical size 2.0 x 1.5 meters, as well as an ultrasonic tracking system – InterSense IS-600 used to track hands. During the sessions participants wore custom-designed interaction gloves that contained the sensors. The gloves were made in Lycra to allow a comfortable fit for different sizes of hands. Participants stood in front of the screen. The application was written in C# and used OpenGL for visualization purposes. Both the presentation and replay parts of the prototype were fully functional. The analysis phase, where the presentation is segmented, was done manually.

5.5.6 Findings

General principles

Designers were positive about the general underlying principles behind the tool. In general terms, they agreed with the way the tool provided support for presenting MBs:

× *"I think that with this system you can easily identify different parts of the presentation and play them back again. In a way, you have removed the presenter but you have kept the gestures and the impact the gestures make, which is nice." [P2]*

× *"It's beautiful! I like the idea a lot. It's very stimulating. In case of long and complex presentations this allows you to have reminders of where certain parts of the presentation were, something like chapters. You really get the feeling like you see the entire MB and you can focus on the subjects you like by zooming into some parts. The feeling is good, you feel in control of the presentation." [P3]*

× *"I do like the gestures and maybe you could recognize people by (their gesturing) after some time. The way you tag automatically the spots with text that's really beautiful I think. So that's very, very rich." [P10]*

Hand gestures

In the first part of the study where participants were asked to present a MB using the tool, designers were able to interact with the tool with no prior training. They especially liked the naturalness and simplicity of the interaction through hand movements. However, in the second part of the study participants experienced some difficulties when exploring a presentation by triggering sounds. They specifically expressed some concerns about the amount of gestures they would have to perform and fatigue. They also found some of the gestures awkward or uncomfortable to make (e.g. putting both hands together in mid-air to trigger a sound):

× *"It can be a bit heavy in terms of all the gestures you have to make, but it is easy to step into (and move between the different proximity areas). But it's nice that it is physical. It's refreshing!" [P3]*

× *"Bringing both hands together to trigger sounds is very uncomfortable. Maybe (you could do) a quick movement in the air like you are pressing something, or just use your finger." [P4]*

× *"The gestures you are making when presenting are natural, but the gestures you have to make to retrieve information are not. It would be better to make a quick selecting movement." [P6]*

Proximity-based interaction

We also wanted to hear from designers on the idea of using proximity-based interaction. Designers welcomed the introduction of this interaction style to reveal different parts of the tool to support the presentation of MBs. They told us that the coupling between stages or locations and the available activities was natural as can be seen in these comments:

× *"I think it's good because if you step back you immediately make it clear that I want to have the overview. If you go closer you want to have some detail or talk to somebody. And you go back again and you listen and you want to see the whole picture.*

So this is quite logic for me." [P8]

✕   *"If I am sitting at the back then I am the audience, and it's about general things anyway. If you want to go to detail you stand up and you point. I might imagine that the big chief doesn't want to stand up and gesture from his chair. But I agree with the mapping of distance and different functionalities."* [P9]

✕   *"It totally makes sense that you say the place where you are standing at the back is an overview and (you increasingly) get more and more interactive with the system until the point where you are actually touching (the screen) and sending back your comments."* [P10]

Participants mentioned some difficulties in knowing the exact location they were in (i.e. showing, contemplating, replaying, exploring) due to a lack of feedback. This happened especially when designers would move between different parts of the tool (i.e. closer or further away from the display) without performing any hand gestures (i.e. keeping their hands in a resting position next to their body):

✕   *"It's fun! You try to move back and forward, and see what happens in each stage. This type of aesthetics of interaction can trigger new ideas in designers to try new things. I miss some kind of feedback to know where I am standing. There should be dynamic transitions between locations."* [P3]

Visual feedback

Regarding the visual feedback provided by the tool by showing the traces of gestures on top of the MB, the discussions were centered around three main topics: amount of visual information, dynamic gestures, and feedback for previous and next speech segment.

In relation to the amount of visual clutter, participants had different opinions. Some participants commented on the amount of visual clutter that the gestures created while others suggested filtering out or grouping some of the gestures:

✕   *"At a certain point it is getting increasingly cluttered."* [P4]

✕   *"I think the way the visual feedback is presented is done in a subtle way; it does not ruin the impression of the MB."* [P5]

✕   *"The MB disappears behind the gesturing. So it might be good to somehow filter it or simplify it towards blobs because I think it's a bit sad that the MB fades."* [P9]

Participants also commented on the helpfulness of being able to play back the dynamic gestures on top of the MB as they heard the explanation. They especially reflected on the positive impact the dynamic gestures have on the overall presentation. Participants said the dynamic gestures made it richer, more alive, and more human than other types of standalone presentations (i.e. PowerPoint):

✕   *"It helps to better explain the picture. It enriches the experience and gives a touch of sensibility. It makes it easier (for you) to connect. Although you are not there*

present anymore as a designer, it seems that you are there. It is like a ghost of you."
[P1]

× *"It really (makes it) much more alive. I can feel that the designer was there doing*
   those gestures. I think that is nice, it makes it more human." [P2]

× *"(Seeing the dynamic gestures) is funny; you really get the feeling that the designer*
   said this and was pointing while he was doing it. (It feels) like going back in time.
   I think that if you just highlight an image and you hear the story is really different
   than if you see the process of showing that story. I like that a lot!" [P3]

The final aspect of visual feedback that designers reflected on was showing the previous and next speech segment together with the currently selected one. Designers saw this aspect as a bonus as it helped them get into the context of the presentation:

× *"I really liked being able to explore temporally, going back and forth. There is a real*
   nice coupling. In traditional presentations you have no cues about what is happen-
   ing, where am I and where am I going to go next. That is a really nice aspect of this
   tool. This is much more intuitive than just having a timeline or something similar
   because now you can actually see how things unfold temporally alongside the
   thematic unfolding." [P5]

× *"It's good that you indicate the direction in black. That will be the next part of the*
   story. It makes sense." [P1]

Rehearsing presentations

Finally, participants reflected on how the Funky Wall could potentially become a support tool to improve presentation skills. Displaying the gestures in visual form made them more aware of how they use their hands during presentations, which could influence the way they present:

× *"I become more aware of what I am doing. I have to practice to be clear, for example*
   by making circles around images. It's a new way of presenting. It's exciting actually.
   [P1]

× *"I also see it as a rehearsal tool so you can really put up a presentation, see how you*
   did, what you forgot, and improve it." [P2]

× *"It's a good idea for the presenter. It forces you to think of the whole structure of the*
   presentation. This system could help the presenter become a better presenter." [P5]

5.5.7 Discussion

Feasibility of the tool

In our prototype the analysis phase, where the presentation is segmented, was done manually. The main reason for doing this was that the goal of the study was to first assess the potential usefulness and usability of such tool. However, based on the

results reported in the literature and the analysis of gesture-speech synchronization automation, our tool seems feasible [Stifelman 1997].

For segmentation our tool does not need to recognize speech, we only need to detect phrase boundaries. One way of detecting phrase boundaries is by using pauses (intervals of non-speech audio between speech segments) [Wang & Hirschberg 1992]. Stifelman [1997] found that phrases could be robustly identified using a threshold of 155 ms; pauses shorter than the threshold are most likely pauses within a phrase while longer ones are pauses between phrases. The speed and location of gestures can also be used to make the segmentation more robust. In our exploratory study we have observed that speed can be used to separate between explanations of specific parts (slow movements), connections between different parts (fast long movements), and the general discussion of the MB (often fast short movements).

Applying a similar approach to presentations

A similar approach can be used in webcasting, such as ePresence (http://epresence.tv/) or Microsoft webcasts (http://www.microsoft.com/events/). Webcasts are archived and can be accessed many times. By adding a gesture layer we can enrich the presentations, and improve the efficiency and understandability of the presentation. We can also use gestures to create indices or bookmarks that would help to browse through presentations. This is of course more applicable to highly visual presentations that would naturally lead to many pointing and outlining gestures.

Using other media to record and replay

We believe that the use of gestures allows designers to more clearly express the feelings and ideas for a MB and therefore can enrich the presentation and improve the way that the client can later perceive the MB. The same is applicable to the replaying and annotating of the presentation. However the latter part can also be done on any desktop system using a standard pointing device such as a mouse. Part of the richness will be lost, but nevertheless the message can be conveyed. In principle, the presentation could also be done on a desktop but we fear that the added richness will be lost.

Visual vs. audio feedback

Feedback in the tool comes mainly in the form of visual representations. Some participants found it difficult to know exactly in which location they were only based on visual aspects. Providing transitions by means of sound between the different parts of the presentation is something that should be supported to reduce some of the visual clutter.

5.5.8 Conclusions

We introduced the second and final prototype that provides support for the process of making MBs. The Funky Wall is an interactive wall-mounted display tool that supports designers in conveying the story behind MBs in situations when face-to-face communication is not possible. The tool allows designers to easily record MB presentations while capturing the richness of their individual presentation skills and style. The tool also allows both designers and clients to play back, explore and comment on different aspects of the presentation, by following the principles of *intuitive interaction* (section 2.5.5), interacting with the system using hand movements (section 2.4.5) and body position (i.e. proximity).

We have evaluated the tool with professional designers in order to test its usefulness and usability. The results of the study showed that designers saw a practical use of the tool in their design studios. Participants felt that the tool gave them control over the presentation, so they could, with little effort, explore different aspects of the MB. Moreover they felt that the combination of speech and traces of hand movements gives a touch of sensibility and makes it easier to connect with the message. Gestures could be used as a creative tool for expression and aesthetics. Regarding the hand movements, participants also liked the naturalness and simplicity of the interaction. However, just like for the Funky Coffee Table, they also expressed some concerns about fatigue in terms of how much time they would be able to work with the tool with their hands in the air.

The exercise of designing, implementing and evaluating the Funky Wall tool has taught us several lessons that are applicable to other situations where face-to-face communication is not available, such as webcasting or e-learning. We believe the three-layer approach we harnessed can potentially allow more flexible presentation browsing while also reducing the required bandwidth.

5.6   Discussion

5.6.1 Design considerations

In chapter 3, we identified considerations for a MB making tool (section 3.8). We will now check to what extent the tools we developed reflect those considerations.

Support idea development

We have identified five stages of the MB making process. Out of those stages, the first four traditionally belong to the making of the MB (*collecting, browsing, connecting* and *building*), taking early discussion topics and developing them into more mature ideas. The Funky Coffee Table fits within this part of the process. The fifth stage of the process (*presenting*) explores what happens to the ideas contained in the MB once the MB designer has completed it and they are shared to the outside

world. The Funky Wall supports this part of the process. However, to fully support idea development, maybe we should have developed a third tool that supports the early discussion rounds between client and MB designer, or the early inception of ideas. The MB making process would then become a more simplified process with three general stages: inception (beginning), creation (making), and presentation (the after-life).

Encourage two-way communication

The Funky Wall achieves this by supporting asynchronous and remote presenta-tions of MBs when face-to-face communication is not possible. We believe that nothing beats the richness in communication of a co-located presentation. Our tool tries to allow making a presentation asynchronously and remotely, while capturing the richness of a co-located presentation by dynamically playing back the gesturing and the speech made by the designer.

Involving the senses

Both the Funky Coffee Table and the Funky Wall provide users with multimodal feedback. Throughout the interaction, the tools provide audiovisual feedback on the current state of the tool. Additionally, the Funky Coffee Table provides a horizon-tal surface for designers to touch and guide their browsing gestures (i.e. flipping and flicking). The Funky Wall adds the extra dimensions of time and movement to automatically index the presentation and dynamically display the gestures made by the presenter.

Holistic interactive space

The two tools we developed expressed our *funky-design-spaces* hypothesis. We em-phasized the importance of an integrated environment in supporting the creation of MBs with AR. The Funky Coffee Table and the Funky Wall were conceived as separate interactive tools that concentrate on specific parts of the MB making pro-cess. Although we did not develop the connectivity and sharing part of the concept, once all parts of the interactive design space would be functional it should be pos-sible to easily share and transfer materials or contents from one place to another, as expressed in some of the ideas generated during the co-design sessions.

Merging with the real context

The Funky Coffee Table does this by providing support in a relaxed setting on a coffee table while designers are comfortably seated on a couch. The Funky Wall is set up in a more formal yet natural setting for the task of giving a presentation by standing up in front of a wall display as they show their work.

Flexible and intuitive interaction

The Funky Coffee Table provides flexible and intuitive interaction for MB designers by allowing them to work using hand movements (gestures). Inspired in the current way MB designers browse, select, and create soft-piles of images, the tool encourages MB designer to work with both hands collaboratively towards achieving a goal. MB designers wear hand-made interaction gloves that participants thought were comfortable and unobtrusive.

The Funky Wall provides flexible and intuitive interaction through hand movements (gestures), and body position (proximity). MB designers are able to simply walk up to the screen and start gesturing and explaining the MB to their clients. Due to the simplicity of the tool, little or no prior training is needed for the MB designers to be able to interact with the tool. MB designers wear the same gloves as for the Funky Coffee Table.

5.6.2 Funky-design-spaces hypothesis

Our *funky-design-spaces* hypothesis introduces the vision of a new holistic design studio, a comfortable space in which AR tools provide support for the creation of MBs. These tools should be interconnected and stimulate designers to break away from their desks inside their design studios.

Up to this point, the Funky Coffee Table and Funky Wall prototypes had only been evaluated with practicing designers in isolation. We had very little clues about how participants perceived the idea of this holistic designs studio that our *funky-design-spaces* hypothesis was trying to introduce. Therefore, we decided to conduct an extra evaluation of both tools working alongside each other.

Evaluation

The main purpose of this evaluation was to see to what extent the tools we had created expressed our *funky-design-spaces* hypothesis and to try to provide answers to our research questions on how and why designers create MBs and how AR tools can provide support for this activity. The evaluation was conducted with six practicing designers with at least five years of experience. The participants varied in gender (1 female, 5 male), age (between 30 and 46), and dominant hand (5 right, 1 left). The evaluations were conducted individually. All sessions were recorded on video.

Setup

The evaluation consisted of two parts. In the first part of the session participants experienced both tools (Figure 60). One half began with the Funky Coffee Table and the other half with the Funky Wall, later switching to try the other tool. Participants were asked to perform the same tasks previously described for each tool. Participants spent on average 20 minutes per tool.
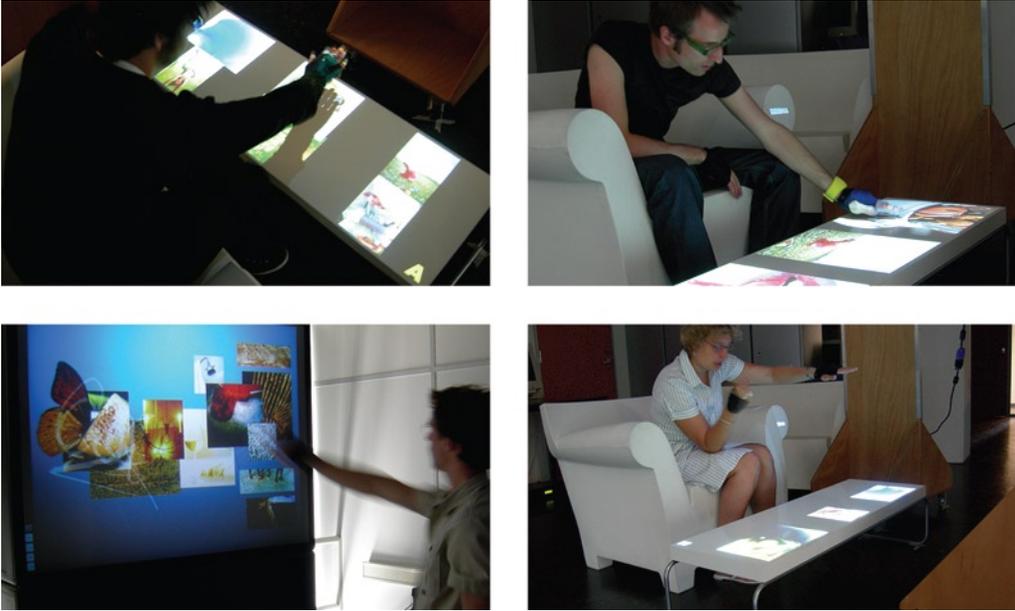
Figure 60. Evaluating the Funky Coffee Table and Funky Wall to test our funky-design-spaces hypothesis

Funky Coffee Table (top-left) – Piling an image into layer 'A' using the dominant hand

Funky Coffee Table (top-right) – Reviewing layer contents with the non-dominant hand

Funky Wall (bottom-left) – Exploring specific parts of the presentation using the dominant hand

Experiment setup (bottom-right) – Experiment setup with the coffee table and small couch. The larger couch seen on the background faced the large screen used for the Funky Wall

In the second part of the study, we asked participants to share their views on our *funky-design-spaces* hypothesis, specifically on our idea of supporting the process of making MBs with AR by having distributed interconnected tools instead of a single centralized system on which designers perform most of their tasks and spend most of their time. This discussion lasted for 10 minutes, on average per participant. The average total time of the session per participant was 1 hour.

Findings

As a first general remark, participants agreed with the vision of a holistic design studio housing interconnected tools that stimulate designers to break away from their desks, and thus proved the *funky-design-spaces* hypothesis true. Designers also reflected on how these spaces could and should encourage collaboration with more people:

×   *"It's good that you support working in different situations not always sitting boringly behind your screen." [P2]*

×   *"It's much better to have different activities in different places within the design studio. The problem of doing it in front of a computer is that you are on your own, alone in front of the computer. Now, for example someone else could be sitting here (points) and another one there (points), and all could be browsing simultaneously. So three persons can be working together. Or then you could imagine that you could use these things for focus groups and things like that. So it's not just designers that can use it. It would also be a way to make the world of the designer closer to the user." [P1]*

×   *"Personally, I don't think I would use a single device for making MBs. So, yes, I agree with your vision of having distributed functionalities." [P3]*

×   *"You could use the table to browse images and magazines in less solitude, and the same goes for the wall." [P6]*

Regarding our research question on how AR tools can provide support for the creation of MBs, participants were positive about the proposed interaction styles and functionality. Participants reflected both on the use of the orthogonal distance from the interactive surface as a cue for interaction and the use of hands as the main input mechanism. Regarding the use of distance for interaction, participants identified both positive (i.e. extra space) and negative aspects (i.e. lack of physicality) of interacting in open space (i.e. midair). Regarding asymmetric two-handed interaction, designers found similarities between tools and the use of one hand to select and the other hand to perform an action:

×   *"I agree because as I said, even though I want to have less chaos in my office because I need my space, at the same time I still want to see the pile and how big it is. When I have enough to work with, it may be 20 or 25 images, then I want to move towards the screen where I make it. So for me it still needs to have the physical world that I have but you translated it into another physical world into using distance as a cue for interaction and I like that. Maybe I am missing the physicality of it (in midair). In a way the table is already a touch screen so it comes very close to what I want." [P4]*

×   *"(Using gestures) feels good for me because it's a bit the same with (the wall triggering sounds) and the table where you choose a layer with one hand and activate with the other." [P6]*

×   *"What is really new here is the use of distance for interaction which is very clear. If you know the system, you know where you are." [P6]*

The table and wall prototypes allowed them to go beyond the functionalities provided by the tools and imagine how the tools would work together. Designers reflected on how information would be transferred from one tool to another, as can be seen in these comments:

× *"I see this table in a meeting room for example. And then having the images on a projector so you can make groups of images and then put it on the wall and the images appear there, and you have different groups and you can move it there on the wall. So it's like a selecting table." [P1]*

× *"If you have places within one room, it should be easily shareable and also somehow clear what the other is trying to communicate to you in any stage of the MB making process." [P3]*

5.7   Conclusions

For my *research through design* process, I designed two tools to test my hypothesis of *funky-design-spaces*. The initial idea was to co-design together with designers AR tools that would support the creation of MBs. Due to time restraints I developed one tool before conducting the co-design sessions and a second tool in between the Finnish and Dutch co-design sessions. Nevertheless, some ideas closely related to the Funky Wall tool emerged in the Dutch sessions after the tool had been completed.

Both tools allowed me to test my *funky-design-spaces* hypothesis, which was proved true as expressed by participants during the evaluations of the tools. Participants agreed with the notion of tools that stimulate designers to break away from their desk.

The process of making MBs as described in section 5.6.1, consists of three general stages: inception (beginning), creation (making), and presentation (the after-life). The Funky Coffee Table provides support for one part of the creation stage (i.e. *browsing*). The Funky Wall provides support for the final stage of the MB making process, the presentation stage.

Both the Funky Coffee Table and the Funky Wall provide a flexible and intuitive interaction through hand movements (gestures) tracked by means of interactive gloves. The tools also merge with the real context of the activity and the location in the design studio. Finally, I introduced 'z' or the orthogonal distance from the interactive surface as a cue for interaction.

In the case of the Funky Coffee Table, using the space above the table allowed creating extra space for storing and handling images. However, it produced at the same time a discrepancy for interaction between the action and perception space. Some designers found it difficult to interact with images in situations where the action space is set in mid-air and the perception space is located a table-level, such as for rearranging piles of images. Designers tried to interact with the images where they were perceived (table-level) instead of in mid-air. Although they were all able to overcome the problem upon further exploration, these findings raise issues with regards to my choice for supporting interaction above the table versus other alternatives such as around the table. Regarding the use of hand movements, although

participants were positive on its naturalness and simplicity as an input method, they were also concerned about fatigue and how much time they would have to keep their hands in mid-air.

Regarding the Funky Wall, I used distance from the vertical display to design proximity-based interaction to reveal different parts of the tool that supports the presentation of MBs. Here, designers welcomed the introduction of this interaction style to support different functions of the tool. However, they also mentioned some difficulties in knowing the exact location they were in only based on visual feedback. Designers proposed the use of audio transitions that would allow providing better feedback and at the same time reducing visual clutter. Regarding the use of hand movements, they also expressed some concerns on the amount of gestures they have to perform and they even found some of the gestures uncomfortable to make.

REFLECTIONS

6 Reflections

This final chapter consists of a set of reflections on the research presented in this thesis. A first reflection on the extent to which the activities and user studies described in the preceding chapters address the specific research questions is presented, followed by a second reflection on the complete process. Finally, a reflection on limitations and future work is discussed.

6.1 On the research questions

6.1.1 Question 1: What are MBs and why do designers use them

This research question was directly derived from design practice through the studies described in chapter 2. The use of MBs is a love it or hate it issue [McDonagh & Storer 2005a] for designers and students, and this thesis is greatly influenced by trying to understand why. In chapter 3, the essence of MBs is explored. The results of the contextual inquiries with Dutch and Finnish designers consist of a definition and a work-modeling diagram that describes the process of making MBs in detail. These results are later shared and discussed with Finnish and Dutch participants in co-design sessions in chapter 4. Finally, MBs are further explored in chapter 5 by checking the relevance of the support provided by the Funky Coffee Table and Funky Wall tools for MB creation and communication.

In total, excluding the study with design students, 50 (different) practicing designers participated in the studies. With an average experience in industry of ten years (33 years of age in average), the participants made up for around 500 years of experience with MBs.

Based on the results of these studies, the following definition is proposed by the author (section 3.7.1):

× *MBs are an idea development tool used by designers and their clients to communicate, think, and share their different views that emerge from the design brief while defining future products, services or trends. Although different types of media can be used, they mostly consist of images used in different levels of abstraction to tell a story about the company, product, or audience, and setting a direction for design. There is no right or unique interpretation of a MB.*

Each study enriches our understanding of what a MB is. In the first contextual inquiry Dutch designers indicate that MB makers specialize in creating MBs and can then pass the rest of the work to other design professionals. The second study consisting of MB interviews with Finnish designers opens up our views on MBs by seeing designers that use MBs as part of their own complete design process. In the *dialogue-labs* our definition of MBs is shared with designers to expand our understanding of MBs. Participants tend to agree with the definition and bring new insights based on the proposed definition. Finally, our understanding of MBs is put

to the test from the perspective of the tools we have created.

So why do MBs stir up such mixed emotions in designers and students alike? According to McDonagh and Denton [2005b] MBs remain largely an item of faith in the design community. In this thesis I have tried to shed some light on the issue. One of the skills required to successfully create MBs consists of having the ability to work with images on different levels of abstraction. Experience and thus age play a big role in developing this ability to build meaning and understanding of how to work with images. Therefore, it becomes difficult for students who are taking their first steps working with images to understand the real value of using MBs. To them, MBs sometimes feel like a meaningless addition to a project's list of deliverables [Garner & McDonagh-Philp 2001]. Some participants suggested that students who are in fourth or fifth year of design education can understand and work on an abstract level which is necessary to work with images, and not before that. Moreover, some students are unable to work with MBs even after they graduate. This brings us to the issue of practicing designers who hate or do not believe in MBs.

In chapter 4, we discovered differences in creativity, and willingness to let go and get started with the creative tasks. This would indicate that designers are not equally creative or equally equipped with the tools and skills to perform their work. Howard Gardner proposes the following definition of intelligence [Gardner 1999]: "The ability to solve problems or to create products that are valued within one or more cultural settings." Gardner emphasizes how our mind is split into modules, which can be seen in the rich variety of our abilities and creative domains. We all have different skills, and different people show how skilled they can be in some areas and not in others. At the Department of Industrial Design of the TU/e a competency-based educational model has been applied since 2001. Similar to Gardner's constructivist conception of intelligence, which takes into account that students learn in different ways [Lucero *et al.* 2006], the competency-based model consists of ten competency areas or abilities that students must develop. At the end of their studies, students will have been responsible for their own individual learning and thus their competency development or skills will vary from one student to another. Their development can be usually visualized as a spider (or star) chart, but also as a graphic equalizer of an audio component where each band corresponds to an ability. Just as designers and students have different skills in idea generation, concept development, technology, empathy, marketing, sketching, visualizing teamwork, reasoning, reflection, or logic, so too do they have different abilities to work with the levels of abstraction needed to make MBs.

6.1.2 Question 2: How can AR tools provide support for professional users in their work

This question is directly related to the results of the *funky-design-spaces* hypothesis.

The results of the evaluations of the Funky Coffee Table and Funky Wall seem to indicate that designers do see an advantage in the support provided by the tools and thus would be willing to change their current work practices. Although the tools can be improved and the *funky-design-spaces* (i.e. the five stages) have not been completely brought to life, the existing tools allow designers to get a glimpse of the vision behind our hypothesis. Designers agreed with the notion of tools that stimulate them to break away from their desks. A couple of designers suggested that some of these stages might even be grouped, such as for *browsing* and *connecting*.

Intuitive interaction is proposed as a perspective on providing AR support for professional users in their work. The first idea behind *intuitive interaction* is allowing people to simply walk up to a tool and begin interacting with it using their current skills and knowledge on the task that is being supported. There is no need for long explanations or time getting used to the tool, therefore people should be able to interact with the tool with little or no prior training. The key question here is that, because the tool fits the skills and the supported task, then as a result training is not required. Thus training the use of the tool is not the key question. Second, *intuitive interaction* means allowing designers to freely use their hands as the main input mechanism for activities that involve creation. Designers wear custom-made interactive Lycra® gloves that contain sensors so that the tool can track their hand movements. The gloves are not perceived as a tangible interaction device but simply as a way to track hand movements. Later, speech is added as an extra way of interacting with the system. A third component of *intuitive interaction* is taking use contexts into account or the ability of the tools to merge with the existing possibilities of a design studio environment. Finally, a new cue for interaction is introduced as part of this idea of *intuitive interaction*. Both tools use the orthogonal distance from the interactive surface (or 'z') to generate extra interaction space, and to hide and reveal different functions of the tools. In summary, the four main aspects behind *intuitive interaction* are:

× *Builds on people's current skills and knowledge on the supported task*
× *Uses hands as main input mechanism for tasks involving creation*
× *Tools must merge with the real context*
× *Use of the orthogonal distance from the interactive surface as cue for interaction*

These four aspects were put to the test when designers evaluated the tools. According to the results, participants were mostly positive about the general notion and the ideas behind *intuitive interaction*. The tools were evaluated positively for building on people's current skills and merging with the real context. Although participants agreed with the interaction principles behind the use of hand gestures and orthogonal distance from the surface to interact, these two aspects can be improved. Aspects such as mental models, fatigue, visual and auditory feedback, and transitions between areas can be further explored.

6.2   On the research process

The relevance of the work described in this thesis refers to an academic context with its main purpose being knowledge generation. However, as stated in the introduction (section 1.3), I was also interested in the overall research process with regards to the use of different UCD methods to unveil the needs of users, not only in an academic context, but also in an industrial one. In this section I plan to move towards an industrial context to reflect on some of the lessons learned along the way.

How realistic is a three-year design process like the one described in this thesis? Would project leaders and managers be willing to use this amount of resources in an industrial context? Can this process be carried out in a shorter time span? These are all fair questions that I will try to reflect upon.

6.2.1 How realistic is it?

For an industrial context where time is money, for sure the process described in this thesis is unrealistic. Having to wait for three years before seeing the results of the design process is something that is acceptable for a research project like this, but not for industry. I have been constantly thinking about this point during my long process. In discussions with fellow researchers I have been trying to quantify exactly how much shorter this process could have been.

In a personal communication with Tuuli Mattelmäki who did her Doctoral thesis on design probes, I specifically asked her how short could a probes study become? Her first reaction was, *"people always ask me this question"*, proving it was a relevant one. After initially hesitating to respond she replied: *"If you have a larger team, then it could take three weeks: one for preparation, one for deployment, and one for analysis."* Compared to the eight months my probes study took, three weeks was quite an improvement. Having more than one person preparing, deploying and analyzing the probes sure would speed up things, but would the results be any different?

The probes study allowed me to find a focus for research (i.e. supporting the creation of MBs). As the project progressed, efficiency gradually increased with every subsequent user study. As I had a clearer idea of what had to be done the resources used in terms of time for each study were less and less and I was able to involve more designers per study. For example, the four contextual inquiries with Dutch designers took a total of four months, while the ten MB interviews with Finnish designers took five months, both including the final analysis. With each participant I became more experienced in preparing and conducting the interviews. I knew better what to look for, what to ask, when to remain silent, and when it was time to leave as I had collected sufficient information.

The co-design sessions were probably the best case of efficiency in terms of resources. It took four weeks to prepare and conduct four *dialogue-labs* sessions in Fin-

land: one week to plan the sessions, two weeks to prepare the materials and contact the participants, and one week to conduct the sessions. Since the materials used in the Dutch sessions were basically the same and thus less preparation was required, it took 3 days to conduct three *dialogue-labs* sessions in the Netherlands. A vital aspect in this case was having Kirsikka Vaajakallio as a second researcher involved in preparing and conducting the sessions both in Finland and in the Netherlands. Kirsikka had previous experience conducting similar creative sessions to allow participants express their ideas using physical materials [Vaajakallio & Mattelmäki 2007]. Our joint experience helped us speed things up as the sessions progressed. In an industrial context, *dialogue-labs* could be conducted in four weeks: planning the sessions, preparing the materials, conducting the sessions, and doing the analysis would take one week each. The time required to conduct the sessions might vary depending on the number of sessions planned. Due to the amount of information generated during each session, team members can only participate in one session per day.

Regarding the development of the tools, it took Dzmitry Aliakseyeu and me three months to conceive, discuss, design, and implement each of the Funky Coffee Table and Funky Wall prototypes. Again, having the invaluable experience and help of Dima to create the prototypes proved a key point in having a shorter development time. As the project progressed, the resources used in terms of time became closer and closer to industry standards.

6.2.2 Shortening the process

In an attempt to try to shorten the process described in this thesis we set up a project that would basically consist of performing similar tasks but in a shorter time frame. TU/e Industrial Design student Eveline Brink did a three-month project on how to bring the *funky-design-spaces* research hypothesis to life from the perspective of industrial design students. Her main tasks were to conduct a probes study (with probe interviews) and *dialogue-labs* that would be translated into proposals to redesign the space of the VIP lab of our department (Figure 61). In those three months she was able to 1) successfully conduct a probes study with ten students, 2) analyze the data and create posters with simple diagrams and drawings for probes interviews, and finally 3) conduct three *dialogue-labs* with a total of eight participants (excluding herself). Using the data collected during the sessions (i.e. video, pictures, artifacts and questionnaires) she identified 64 ideas that were subsequently summarized into 12 directions for design, which were then translated into 4 scenarios. This example shows that it is indeed possible to dramatically shorten the resources used in terms of time for a long process such as the one described in this thesis.

Figure 61. Different aspects of *dialogue-labs* with industrial design students

Eveline Brink conducted three dialogue-labs to co-create proposals to redesign the space of the VIP lab of our

department from the perspective of industrial design students. The sessions took place inside the actual VIP

lab that was arranged to look and feel more like a design studio than a research lab. The sessions included

probe interviews, different actitivities and materials to get the dialogue going

But is the quality of the materials and the results affected by shortening the process in such a way? There are several examples in industry that indicate that this should not be the case. An example of high-quality materials that can be achieved in a short time is the probe kit prepared by UTEM (Chile) Visual Communication Design students Francisca Arévalo and Luis Núñez. Using their probe kit (Figure 62), they tried to capture the dreams and aspirations of the individual members of independent rock bands who were seeking to communicate their visual identity. In three weeks they were able to prepare, deploy and analyze the kit contents. Based on the quality of the materials they produced (both visual and content-wise), as well as on the richness of their results, it becomes clear that less time to prepare the kits does not necessarily mean less quality. These students were able to produce at their best level both in terms of efficiency and effectiveness within the three-week time frame.
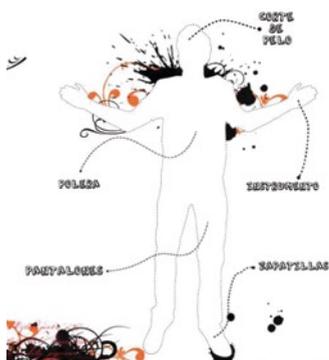
Figure 62. Sample pages from the "Masa: Hágalo usted mismo" probe kit (diary)

Francisca Arévalo and Luis Núñez created high- quality probe materials in spite of

the limited available time. The kit was meant to capture the dreams and aspirations of

(music) band members to create an identity for the band

6.3   On the limitations and future work

6.3.1 Iterative design cycles

The work described in this thesis consists of a single long design cycle up to the point of the co-design sessions (chapter 4), followed by two short design iterations that resulted in the two prototypes that were designed and evaluated (chapter 5). The process includes iterations within stages in the sense of constantly going back to enrich our understanding of the problem before moving on. For instance, in chapter 3 the results of our Dutch contextual inquiries were tested against the findings of the Finnish MB interviews. In chapter 4, the ideas that emerged from the Finnish *dialogue-labs* were compared to the results of the Dutch *dialogue-labs*. Finally, in chapter 5 the knowledge gained by designing, implementing and evaluating the Funky Coffee Table was complemented with the acquired knowledge of going through the same process for the Funky Wall. By testing both tools together we were able to test our *funky-design-spaces* research hypothesis. Instead of this being a linear process, the design solutions evolved through iteration, an inherent feature of design. Keinonen *et al.* [2008] argue that the final solution to a (design) problem can be triggered in any phase within the iterative loop. This goes back to the discussion on design paradigms (section 1.4), and how the design process I am supporting is by nature explorative, open, and flexible and thus better responds to the dynamic, multidisciplinary, and multicultural work needed to create future interactive intelligent products and services.

A new opportunity for further research consists of doing several shorter iterations of the process. For example, a first iteration of the process might consist of conducting a probes study with a general research or design problem in mind and quickly developing a tool based on the knowledge gained up to that point. The first iteration could already include some initial user involvement in co-designing during the probing interviews or in future workshops [Kensing & Halskov 1992]. A second iteration could consist of conducting contextual inquiries to further explore and expand the knowledge on the problem, and again co-design with users in more structured *dialogue-labs* that lead to the implementation and design of an improved version of the previous tool or a new tool altogether. A third iteration might include semi-structured interviews with again co-design activities and maybe even exploring *co-development*. It would be interesting to compare how much the results obtained by the end of the third iteration differ from the results presented in this thesis.

6.3.2 Co-design, co-creation and co-development

Traditionally, practitioners have involved users at both ends of the design process: in the beginning to understand the problem from a user perspective, and at the end of the process in (usability) evaluations of the proposed designs. However in this

thesis I argue that users should drive the innovation process by involving them all along the way.

The term *co-design* has been used to refer to the work described in this thesis. *Co-design* is a general term used to indicate collective creativity as it is applied across the whole span of a design process [Sanders & Stappers 2008]. According to Sanders and Stappers *co-creation* specifically addresses collective creativity that takes place at the beginning of *co-designing* or in the fuzzy front end of product, service, or interface development. The process described in this thesis has in their view (and also mine) mainly covered aspects of *co-creation* and to a lesser degree aspects related to an area that remains largely unexplored: *co-development*.

Co-development consists of involving end-users in the final stages of the design process, when decisions are being made. Hence, *co-development* addresses collective analysis and decision-making at the later stages of product, service, or interface development. Within this new paradigm of *co-design* (Figure 63), the role of practitioners is to first involve potential end users in *co-creation* activities by carefully preparing materials that seek to amplify the creativity of everyday people [Sanders 2006b], such as the activities described in chapter 4. Similarly, the role of practitioners would then be to engage users in *co-development* activities that amplify the analytical-thinking and decision-making skills of everyday people. *Co-development* methods should aim at allowing everyday people prototype, experience, and help the whole team address the feasibility of the final designs that reach the development phase.

Just as *co-creation* activities do not require everyday people to become experts in color theory, materials, or computer programs (e.g. Photoshop®, Illustrator®, Flash®) to generate ideas, *co-development* activities should not oblige everyday people to know about algorithms, databases or master programming languages (e.g. ActionScript, C#, Java, Ajax) in order to assess the feasibility of the final ideas. *Co-development* differs from end-user programming [EUSES 2008] in the sense that the latter deals with everyday people who actually use programming languages as part of their work. *Co-development* also differs from extreme programming [XProgramming 2008] as the latter seeks to involve the whole team together (programmers, testers, analysts, coach, and manager) in programming activities including a business representative or customer who represents everyday people but who not necessarily is a real user.

Sanders and Stappers [2008] argue that one of the reasons it has taken so long for *co-creation* to have an impact in industry is connected to resistance from existing power structures to give the power to end-users. I have witnessed similar initial reticence from designers towards the idea of *co-design* when presenting the *dialogue-labs* at an HCI conference. Practitioners, especially programmers, might be reluctant to engage users in *co-development* activities due to the decision-making power they would have to give away. Both designers and programmers might have to partly give
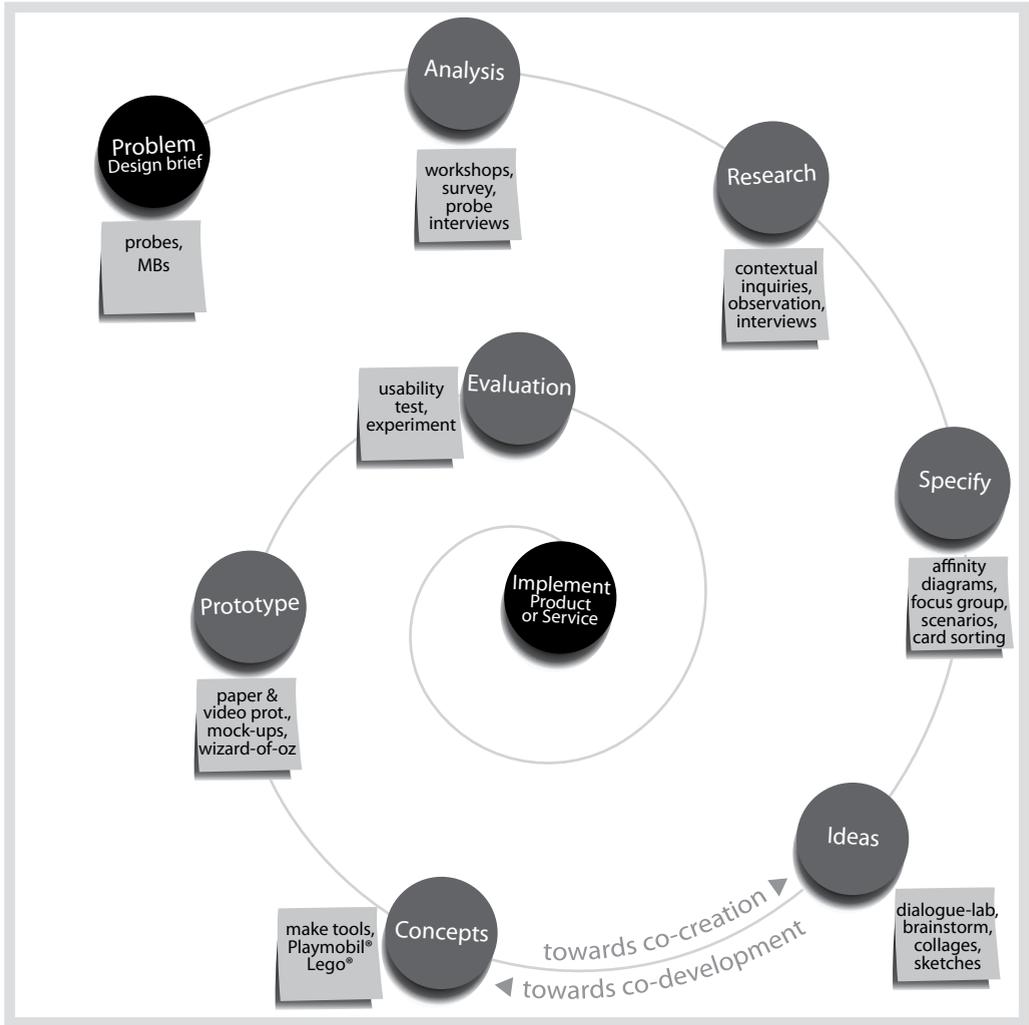
Figure 63. Stages and methods in a co-design process

Nine stages of the co-design process are represented as circular Post-it® notes while the methods for each stage are represented as regular notes. At the beginning of the process practitioners and users engage in co-creation activities. Chances are they will become increasingly involved in co-development activities as they get closer to the end of the process

up the control they have now. If the result of giving a voice to people is having products, services, and interactions that make more sense to users, then it is a sacrifice worth making.

Another alternative for future research is then to explore the idea of *co-development*. What is *co-development*? Can it be applied for any design or research problem? The user would become another member of the development team, with a say in the decisions that are being made. If the users are experts in practice to consult and involve them to understand the context, narrow down the problem, think and prototype novel solutions then it only seems natural to involve them in the development as well. Some methods such as Make Tools [Sanders & William 2001, Vaajakallio & Mattelmäki 2007] allow practitioners to involve users in early *co-development* by quickly building solutions in the real context.

6.3.3 Co-designing with designers

Sanders [2006a] suggests involving everyday people as active participants in the design and production processes, adapting products to better meet their own needs. When the task is to co-design tools that support the work of designers, can designers still be considered as everyday people? Of course, if designers are invited to participate based on their experience as practitioners. Then designers can be everyday people. It is not my intention to suggest that designers should be the privileged and exclusive participants in co-design activities. Actually, the assumption that all designers are (equally) creative or that they are more creative than non-designers is at least questionable. For example, the results presented in chapter 4 indicate that some extra facilitation and guidance was needed for some participants that were less willing to open up and engage in design activities.

A direction for future research might include involving other user groups (non-designers) in co-design activities, letting these potential users guide the innovation process. Usually elderly and children first come to mind when thinking of alternative user groups. Among the latter, Wouter Sluis-Thiescheffer [Thang *et al.* 2008] is working on comparing the quality of the ideas that emerge during co-designs sessions with children by using two methods: brainstorming and prototyping. Although he is mostly interested in the quality of the resulting ideas, he has found out that brainstorming generates more creative solutions while the results of prototyping are more relevant and workable.

6.3.4 Funky-design-spaces hypothesis

The vision for the *funky-design-spaces* hypothesis includes several interconnected tools that stimulate designers to break away from their desks and move around

their design studios to support the creation of MBs. Our final understanding of the MB-making process includes six stages:

×   *Defining*
×   *Collecting*
×   *Browsing – Funky Coffee Table*
×   *Connecting*
×   *Building*
×   *Presenting – Funky Wall*

Two tools were designed and evaluated to test this hypothesis. The Funky Coffee Table and Funky Wall provide support for *browsing* and *presenting* respectively.

The Funky Coffee Table introduced some conceptual difficulties for interaction regarding the mental model from the users and the one I was trying to introduce (section 5.4.7). For rearranging piles of images, there is a discrepancy between the action space (set in mid-air) and the perception space (located at table-level). This problem was introduced by using 'z' or the orthogonal distance from the interactive surface as a cue for interaction. One way to circumvent this problem is to use 'y' instead of 'z' as a cue for interaction. Each row of images corresponding to one magazine or pile is browsed horizontally using 'x', and then designers can use 'y' to move to other groups of images or magazines. Another way of avoiding this problem by using a combination of 'x' and 'y' is to assign different actions the eight points of the compass. East and West would correspond to browsing backward and forward while the remaining six cardinal and ordinal directions could be used for piling images by throwing images in one of these directions. The actions would be performed almost automatically so that the attention is always focused on the work. Another improvement for the Funky Coffee Table could be to retrieve the layer contents by using gestures to indicate the number of the layer with your fingers on the table or the direction where the layer is located by pointing with a finger. Finally, using 'y' instead of 'z' as a cue for interaction would also remove the need for designers to keep their hands in mid-air thus avoiding fatigue.

Regarding the Funky Wall, while using the distance from the vertical display (i.e. proximity-based interaction) allowed designers to easily reveal different parts of the tool, at some points it became difficult for them to know exactly in which location they were based on visual feedback only. This happened especially in some cases when designers would walk closer or further away from the tool without performing any hand gestures. One way to tackle this issue is to add an extra sensor that would only track the designer's position with respect to the screen independent from the hand gesturing together with audio transitions that would indicate moving from one location to another. Regarding the gestures as such, participants were again concerned about fatigue and the awkwardness of some of the gestures (e.g. putting

both hands together in mid-air to trigger a sound). One solution here could be to design a different set of gestures that would allow selecting and triggering by doing a quick movement in mid-air pointing towards (or pressing) a specific sound or part of the presentation.

An interesting line of future research is to co-design and evaluate tools that support the remaining four stages of the MB-making process, namely *defining, collecting, connecting,* and *building*. Doing so would allow bringing to life the complete vision behind the *funky-design-spaces* hypothesis. We have partly explored providing support for *connecting* together with Dima Aliakseyeu, Sriram Subramanian, and Carl Gutwin [Aliakseyeu *et al.* 2006a, Aliakseyeu *et al.* 2007] by conducting a user study on how people interact with piles on digital tables. Despite this, support for four stages is missing. It would be interesting to evaluate all six interconnected tools alongside each other to see if people might feel that some of these tools can be naturally grouped back together, so that instead of six tools, designers might only require four. Participants made some comments during the evaluations of the tools that might lead in this direction.

6.3.5 Evaluations

The Funky Coffee Table and Funky Wall tools were evaluated in exploratory user studies with 10 and 12 participants respectively. The sessions lasted on average 40 minutes per participant. We originally wanted to assess the long-term impact of introducing AR tools in work processes by setting out the proposed designs in real context and evaluate their use over a long period of time (i.e. a couple of months). However, along the way we decided to follow the longer and richer route described in chapters 3, 4 and 5 that allowed us to let users drive the innovation process.

A final line of future research consists of setting out the Funky Coffee Table and Funky Wall prototypes together in different design studios for extended periods of time. This sort of evaluation allows observing the appropriation of technology on behalf of designers and the emergence of new uses. In this respect, Ianus Keller [Keller 2005] designed and evaluated Cabinet, a prototype that supports designers in their interaction with collections of visual material. In his work, Ianus exposed Cabinet to the "roughness of the real world." Cabinet was tested in a real context for a period of four weeks in three design agencies. Regarding the appropriation of Cabinet, designers used them in different ways: 1) to organize sketches and translate them to renderings (as an image management application), 2) to analyze graphic designs (as a photo management application), and 3) to organize sketches according to reference materials (as an organizational tool). In particular, the second user found it annoying that her colleagues would mess up her collection. The solution she came up with was to create a pile of images that her colleagues could safely work with and label it

both with a physical Post-it® note with the text *"start here"* and a similar digital note that said *"that means here!"* This sort of social interaction that emerges over longer use with the proposed tools is worth further looking into.

×   *"People who seek the certainty of externally structured, well-defined problems will never appreciate the delight of being a designer." – Nigel Cross.*

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SUMMARY

Summary

People have different ways of communicating with each other and building an understanding in the context of professional work (e.g. face-to-face meetings, phone calls, email, videoconference, etc.). Designers use mood boards as means to communicate and reach agreements with their clients (or within a design team) in the beginning of the design process. Mood boarding helps explore the available design space or range of possibilities that emerge from the design brief. It does so by visualizing rough and undefined ideas using mostly visual materials (i.e. images from books or magazines). A mood board defines and communicates the direction for a design project.

Human-computer interaction researchers have already identified the potential behind interactive vertical and horizontal surfaces as a more natural and familiar setting to design (collaborative) interactions. Traditionally, research in this area has been mostly driven by technology. As a result, one fundamental facet has been missing: the user. For sure, following a technology push approach is one good way of doing research and fostering innovation. However, it is not the only one. In this thesis a user-centered design approach is followed, leading to user-driven innovation. Basically, it implies conducting a series of user studies (i.e. cultural probes, workshops, contextual inquiries, interviews, video observations) to first explore the work (i.e. design practice) of professional users, then identify a relevant task for these professional users (i.e. industrial designers), and finally try to understand the essence of this task before making any attempt of providing support for it with new technologies. Finally, the results of these studies are fed into co-design sessions in which end-users actively create sensible solutions and tools that support their work and in their real context.

This thesis explores why and how designers use mood boards in the early stages of the design process, and how augmented reality can support mood boarding by following a user-centered design approach.

In this thesis a *research through design* approach is followed, in which the design process is used as a form of research to contribute to a design activity. Working prototypes are created from a clear research question and thus can express a hypothesis. The prototypes are put to test in real-life contexts so users can experience them. Knowledge is generated by designing the artifact, by the artifact itself, and by the evaluations of use. The knowledge gained can later be generalized as design recommendations, theories or frameworks. In this *research through design* process the knowledge gained in field observations (chapters 2 and 3) is integrated with the co-designed concepts or *funky-design-spaces* (chapter 4) into experiential tools (chapter 5). The Funky Coffee Table and Funky Wall prototypes are created and later tested to express the *funky-design-spaces* hypothesis and to try to provide answers to the re-

search questions on how and why designers create mood boards and how augmented reality tools can provide support for this activity.

In chapter 2, design practice is studied by means of three studies to provide designers with a sensible augmented reality support tool for their work. The chapter starts with the probes study where design activities are examined from a general perspective. From the probes study a set of important ideas and possible research directions are deduced. The findings are connected to supporting creativity and finding inspiration in the early stages of the design process. Mood boarding is identified as a relevant task for designers and potentially becomes the central activity to support with augmented reality. The chapter continues with the second study, workshops, where probes results are discussed with designers who are also confronted with an augmented reality tool. In the workshops designers see the potential of supporting mood boarding with augmented reality and encourage us to do so. Finally, a student project is presented where the actual making of mood boards is observed using different techniques such as traditional, digital and augmented reality mood boards. The concept of *intuitive interaction* begins to shape up.

Chapter 3 explores mood boarding in depth. An understanding of the essence of mood boards is created by means of two studies. The results of both contextual inquiries with Dutch industrial designers and of mood-board interviews with Finnish textile and fashion designers are introduced. Based on these two studies, the following definition of mood boards is proposed:

× *Mood boards are an idea development tool used by designers and their clients to communicate, think, and share their different views that emerge from the design brief while defining future products, services or trends. Although different types of media can be used, they mostly consist of images used in different levels of abstraction to tell a story about the company, product, or audience, and setting a direction for design. There is no right or unique interpretation of a mood board.*

Based on the results of the two studies with Dutch and Finnish designers, a detailed description of the mood-board making process and a summary of the five main stages of the mood-board making process are also presented. These studies also led to six considerations for a mood-board making tool for designers:

× *Support idea development. Supporting the complete process of making mood boards, the before and after the actual act of building the mood board.*

× *Encourage two-way communication. Encourage communication between the client and the mood-board maker needed for successful mood-board design.*

× *Involving the senses. Mood-board creation on computers is currently heavily restricted to the visual nature of the activity. Other senses should be involved.*

× *Holistic interactive space. Several interconnected tools that support the rich diversity of the activities along the mood-board making process.*

× *Merging with the real context. Carefully addressing the specific context of the*

activity (e.g. relaxed versus formal activities).

×	*Flexible and intuitive interaction. Allowing designers to perform tasks as naturally as they do now by interacting through hand movements as well as other modalities.*

Chapter 3 ends by formulating the *funky-design-spaces* research hypothesis.

In chapter 4, the data from the previous two chapters is fed into co-design sessions with Dutch and Finnish designers. The general idea behind the *funky-design-spaces* hypothesis is tested in the *dialogue-labs* where researchers and people (i.e. designers) collaboratively come up with new concrete ideas that support mood-board making with augmented reality. The idea for the Funky Wall comes directly from the co-design sessions and is explained in the next chapter. The *funky-design-spaces* hypothesis is initially proved true by designers and is put to the test with experiential tools in the next chapter.

Chapter 5 looks at augmented reality tools and technology to further explore the *funky-design-spaces* hypothesis. Two tools, the Funky Coffee Table and Funky Wall are designed, implemented, and evaluated. The knowledge and experience from the previous three chapters are integrated into these two working tools. The results of the evaluation prove the *funky-design-spaces* hypothesis true. The chapter ends by proposing *intuitive interaction* as a perspective on providing augmented reality support for professional users in their work. The four main aspects behind *intuitive interaction* are:

×	*Builds on people's current skills and knowledge on the supported task*

×	*Uses hands as main input mechanism for tasks involving creation*

×	*Tools must merge with the real context*

×	*Use of the orthogonal distance from the interactive surface as cue for interaction*

Finally, chapter 6 rounds off this thesis by reflecting to what extent the activities described in this thesis contribute to our understanding of the research questions, identifying aspects that could also be valuable to other researchers working in similar and different context than mine.

PUBLICATIONS

Publications

Publications (first author)

× *Lucero, Andrés, Dzmitry Aliakseyeu & Jean-Bernard Martens (2008) Funky Wall: Presenting Mood Boards Using Gesture, Speech and Visuals. In Proceedings of AVI '08, ACM, 425-428.*

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× *Lucero, Andrés, Tatiana Lashina, Elmo Diederiks & Tuuli Mattelmäki (2007) How Probes Inform and Influence the Design Process. In Proceedings of DPPI '07, ACM, 377-391.*

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× *Lucero, Andrés & Jean-Bernard Martens (2006) Supporting the Creation of Mood Boards: Industrial Design in Mixed Reality. In Proceedings of TableTop 2006, IEEE, 127-128.*

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Publications (co-author)

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- × *Sriram Subramanian, Dzmitry Aliakseyeu & Andrés Lucero (2006) Multi-layer interaction for digital tables. In Proceedings of UIST '06, ACM, 269-272.*
- × *Aliakseyeu, Dzmitry, Sriram Subramanian, Andrés Lucero & Carl Gutwin (2006) Interacting with piles of artifacts on digital tables. In Proceedings of AVI '06, ACM, 159-162.*
- × *Martens, Jean-Bernard, Andrés Lucero, Bart Naaijkens, Bastiaan Ekeler, Guus Rammeloo, Marcel van Heist, Matthijs Kwak & Max Sakovich (2006) Blue Eye - Making Mood Boards in Augmented Reality. In Adjunct Proceedings of HCI 2006 ENGAGE.*

CURRICULUM VITAE

Curriculum Vitae

Andrés Antonio Lucero Vera was born on September 14, 1974 in Santiago, Chile. After graduating in 1999 in Visual Communication Design from Universidad Tecnológica Metropolitana (UTEM) in Santiago, Chile, he starts working in industry as a graphic and web designer, both for companies and as a freelance designer. He also starts a parallel career in education teaching at his alma mater.

In 2002, he joins the User-System Interaction (USI) program at the Eindhoven University of Technology (TU/e) in the Netherlands where he starts working in interaction design. As part of the USI program he works for one year as a Research Assistant in Philips Research Eindhoven on a project involving the design and evaluation of an interaction solution for an Ambient Lighting System for the Bathroom in HomeLab.

In 2004, he starts his PhD at the Department of Industrial Design at the TU/e, on supporting the work of Industrial Designers with Mixed Reality. His work results in the construction of the Funky Coffee Table and Funky Wall prototypes. During his PhD he teaches industrial design students.

In 2006, he spends 6 months as a Visiting Researcher at the University of Art and Design Helsinki (TAIK) conducting studies with designers as part of his PhD.

In 2008, he starts working for Nokia Research. He lives in Tampere, Finland together with his wife Soledad, their daughter Rayen (2005), and their son Antü (2008).

ANDRES LUCERO VERA

Andrés Antonio Lucero Vera (1974) works as a
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Netherlands and Chile. He has also worked in
design industry as a graphic designer in Chile and
as an interaction designer at Philips Research in
the Netherlands. In his research, he has worked
in several multi-cultural interdisciplinary projects
that apply user-centered design as an approach to
let users guide the innovation process. He has also
developed tools and methods to actively involve
end-users in co-designing interactions, products
and services.