

Experiential Role of Artefacts in Cooperative Design

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ABSTRACT

The role of material artefacts in supporting distributed and co-located work practices has been well acknowledged within HCI and CSCW research. In this paper, we show that in addition to their ecological, coordinative and organizational support, artefacts also play an ‘experiential’ role. In this case, artefacts not only improve efficiency or have a purely functional role (e.g. allowing people to complete tasks quickly), but the materiality, use and manifestations of these artefacts bring quality and richness to people’s performance and help them make better sense of their everyday lives. In a domain such as industrial design, such artefacts play an important role for supporting creativity and innovation. Based on our ethnographic fieldwork on understanding cooperative design practices of industrial design students and researchers, we describe several experiential practices that are supported by design-related artefacts such as sketches, drawings, physical models and explorative prototypes – used and developed in designers’ everyday work. Our main intention in carrying out this kind of research is to develop technologies to support designers’ everyday practices. We believe that with the emergence of ubiquitous computing, there is a growing need to focus on the personal, social and creative side of people’s everyday experiences. By focusing on the experiential practices of designers, we can provide a much broader view in the design of new interactive technologies.

Categories and Subject Descriptors

H.5.m [Information Interfaces and Presentation] (e.g. HCI):
Miscellaneous

General Terms

Design, Human Factors.

Keywords

Ethnography, Design Practices, Material Artefacts, Experiential Aspects

1. INTRODUCTION

Some of the everyday practices within work environments could not be completely replaced by new computing technologies. As Sellen and Harper [25] show, a mundane artefact such as paper

has several advantages such as mobility, portability, sharability, that are not easily substituted by a new digital paper technology. To give an example from a specific work environment like architecture, it has been suggested that the most valuable tools used for computer-aided design (CAD) can complement physical media (e.g. pencil, paper, cardboard, clay) that designers have been using for a long time but cannot replace these physical media [26]. This shows an intimate and coherent connection between material artefacts and the social practices of professionals. HCI and CSCW researchers have increasingly come to realize the importance of material artefacts for understanding cooperative work [12, 13, 24]. Different studies have shown that material artefacts could help better understand cooperative work through their ecological status and through their coordinative and organizational support (see [20] for a review).

Building on our previous work [31], in this paper we attempt to show that material artefacts used and developed in design practices, such as sketches, drawings, physical models, prototypes and so on do not only help in task-based, instrumental or practical purposes of work (e.g. communication and coordination). These material artefacts play an *experiential* role. In Hallnäs and Redström’s [11] terms, experiential means having qualities that go beyond satisfying basic functionalities and bring value to one’s everyday life. The experiential role of artefacts supports richness in people’s performance by adding meaningfulness to their everyday interactions. Understanding the experiential role of artefacts becomes relevant in a creative industry like design. Designers have to be innovative, creative and sometimes playful in order to successfully meet the demands of building new products and services. Designers do not work in a stereotypical or mechanical fashion when designing products. They apply a set of approaches and techniques that are not necessarily related to solving a design problem, rather exploring and playing with new ideas and concepts. Their everyday collaborations go well beyond conversations and talks and involve communication of expressions, feelings and artistic reflections. Hence, designers’ work is inherently experiential. We believe that in order to better support designers’ work and develop new collaborative technologies, we need to understand and support their experiential practices, in addition to their instrumental and practical needs.

Using an ethnomethodological approach (informed by the work of Garfinkel [9]) we have studied everyday design practices within two industrial design departments over the period of eight months. We have applied naturalistic observations and carried out a contextual inquiry of designers and design students. In this paper we show that material artefacts that are associated with design practices facilitate rich experiential practices. We show that the

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C&T’09, June 25–27, 2009, University Park, Pennsylvania, USA.
ACM 978-1-60558-601-4/09/06.

experiential role of material artefacts needs to be assessed at three phases of design: exploration, communication and use. We also describe several examples of experiential practices that designers frequently apply, such as creating an evocative workplace for themselves, exploiting material richness, applying creative social practices, ephemeral collaborations, exploring and playing with artefacts and applying reflective practices.

For the rest of the paper, in section 1.1 we provide a background on the importance of material artefacts in the fields of HCI and CSCW. In section 2, we discuss the importance of supporting user-experience for designers and describe our fieldwork and the context of our research. In section 3 & 4, we provide the results of our fieldwork. Finally, in section 5, we discuss our approach and provide some high level implications for designing new collaborative systems for designers.

1.1 Importance of Artefacts in HCI & CSCW

The role of material artefacts has been well recognized in HCI and CSCW fields. Several studies have shown that material artefacts play an important role in supporting cooperative work [1, 13, 14, 21, 24, 25, 27, 31]. From the literature [e.g. 20], we establish three major aspects of artefacts that are frequently exploited by researchers: Ecological, Coordinative and Organization of Work.

Ecological. The location, positioning and organization of artefacts could provide valuable information about people's everyday practices and their overall context of work. The ecological arrangement of artefacts could allow us to understand what kind of work is being done and how it is done. It has been shown in several CSCW studies [13, 25] that the spatial organization of workspaces is consequential for how the work has been carried out. Kidd [17] shows that ecological patterns of artefacts could support a 'primitive language' that represents work. Here, Kidd argues that personalized (spatial) organization of artefacts (e.g. papers) allows people to make better sense of their work and helps them in being actively informed by it. Additionally, the way these paper-based artefacts are stored in piles or filed becomes an external representation that retains and mediates people's understanding. The physical context and positioning of these artefacts add "meaningfulness" to artefacts or storage of artefacts (e.g. a filing system). Hence, the ecological aspect of artefact could reflect some processes that can be important for understanding work practices.

Coordinative. Various subsets of artefacts used in workspaces, in homes or elsewhere could potentially act as mediators of information. Examples like flight strips [27], notice boards [1], paper documents [25], have shown that some important aspects of work are coordinated through these types of material artefacts. An artefact such as paper can work as a persistent form of information as well as a carrier for information that can be moved in or out of the work space in order to support efficient collaboration amongst different co-workers. For example, Sellen and Harper [25] have utilized the concept of affordances of papers. They showed that the physical properties of paper (being thin, light, porous, opaque, flexible, and so on) afford many different human actions, such as grasping, carrying, manipulating, folding, and in combination with a marking tool, writing on. Sometimes the public availability [13] and their sharedness [21] allow artefacts to act as a coordination tool between different people involved in joint activities.

Organization of Work. The lifecycle of artefacts within a workplace can provide a great deal of information about how the work is organized. In a work organization, information goes through various embodiments, hence the spatio-temporal aspect of these artefacts could lead to an understanding of important processes, protocols or conventions used in the work processes. Schmidt and Wagner [24] show that in architectural practice, a CAD drawing could serve as a layered artefact that facilitates coordination and organization of different activities. A CAD drawing with a specific mix of codes for functions and materials could trigger details about the division of labor (who is responsible for what). For knowledge workers, Kidd [17] shows that the progress of work can be measured by the tangible, spatio-temporal aspects of these artefacts such as piles of papers.

2. USER-EXPERIENCE OF DESIGNERS

Over the last decade, we have seen a substantial growth in the research of user-experience and ways of understanding and designing for user-experiences [5, 8, 11, 18]. The goal is to go beyond supporting people's activities in an effective and efficient manner, and to focus on their pleasure, fulfillment and sense of well being. By user-experience of designers we mean getting insights into designers' activities that are not directly related to solving design problems but are used to support and improve the creative nature of design. For researchers like us, this could be a challenging issue as designers themselves try to design products by developing empathy with their potential end users and their design strategies vary based on different phases of their design process. Wilhelm Dilthey (1833-1911) suggests that experience can be understood by interpreting people's "expressions" in the form of representations, performances, objectifications or texts [6]. These expressions are not isolated, static objects but an inherent part of lived reality and a situated product of some specific physical, social and cultural circumstances.

An important reason to understand designers' experiences is that their working practices cannot be seen only from an instrumental and practical point-of-view. They do not follow a pre-defined, mechanical process for designing innovative and creative products. Their workplaces within design studios are full of design artefacts (e.g. sketches, drawings, physical models). These artefacts support multimodal and ubiquitous communications and touch the artistic, emotional and empathetic side of the designers' thinking, in addition to their instrumental and practical reasoning. This ecological richness of design studios stimulates creativity in a manner that is useful and relevant to the ongoing design tasks. The ways these artefacts are produced and used could indicate the experiential aspects related to designers' everyday work. We believe that to be able to better understand design practices and build technology to support these practices we need to identify these experiential processes that designers apply. In the case of design practices, we believe that designers' experiences could be understood by interpreting different design representations, their use of different artefacts as well as the activities that are supported by these artefacts.

2.1 Research Context & Methods

Industrial designers work on designing a variety of products that involve the use of traditional design activities such as sketching, making physical models and so on as well as utilizing graphical software, hardware, and electronics. We wanted to understand

how industrial designers work; how they communicate with colleagues; tools, methods and approaches they use for designing and so on. We have taken an ethnomethodological approach [9] to understand their design practices and in particular what role material artefacts play in this. The reason to take this kind of approach is to understand industrial designers' work in their everyday work settings as they happen, without attaching any preconceived measures. The overall goal of our research is to develop remote collaborative tools for industrial designers.

The ethnomethodologically informed approach helps in understanding the detailed and observable practices and methods of designers which can reveal mundane and everyday social facts. We studied two industrial design departments over a period of eight months. We used methods such as naturalistic observation, contextual interviews and recorded live group design sessions. In naturalistic observations, we spent a substantial amount of time understanding designers' work over a period of eight months. For the contextual interviews, we invited 10 master's students and 5 designers (design researchers) and asked questions specifically focusing on their design processes and their use of material artefacts related to their design projects. For example, how do designers brain-storm in a team? What methods do they use for developing design concepts? How do they convey ideas? What are their preferred tools for designing? What are the uses and advantages of different design representations? How do they test their design ideas? In addition, we videotaped their collaborative sessions and took pictures of different patterns of working.

The data from our observations and interviews were qualitatively analyzed. Over time, patterns and themes emerged describing different experiential practices of designers and the role artefacts played in those practices. To make our results clearer and more comprehensible, we present our results in two stages. First, we will describe the phases of the design process where artefacts play an experiential role (section 3) and in the second part we will go into details to describe 'how' artefacts help in supporting different experiential practices (section 4).

3. EXPERIENTIAL ROLE OF ARTEFACTS

During our fieldwork with design researchers and design students, we found that it is important to understand the experiential nature of artefacts at three levels of design: exploration, communication and use (figure 1). *Exploration* level refers to an early stage of design where designers or design researchers use different methods to understand the problem and the situation that they are designing for. *Communication* level refers to the phase where designers collaboratively develop ideas and concepts using different methods and techniques. *Use* level refers to the phase where designers try to evaluate and test their ideas and concepts amongst themselves and with prospective users. There are blurred boundaries between these design levels and it is only in order to associate different artefacts with these design phases that (see figure 1) we apply this kind of classification.

As can be seen in the figure, there is a list of material artefacts associated with these three phases of design. There are mainly two types of artefacts, those that are already in the environment and those that are created by designers. We will take both into account in our analysis. We believe that an understanding of the experiential role of material artefacts could lead to a detailed analysis of designers' practices. In the following, we will discuss the three levels.

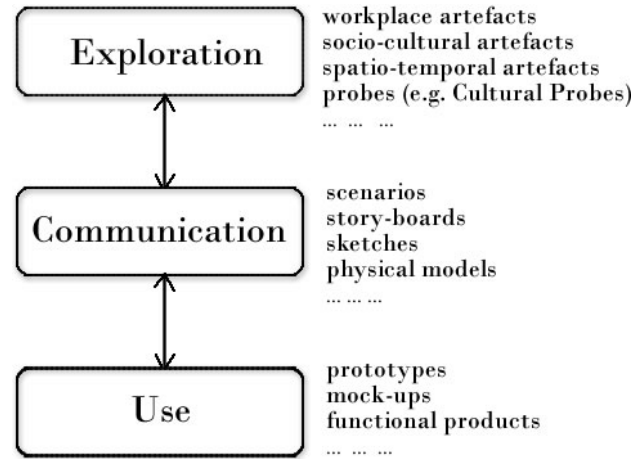


Figure 1: Three levels of a typical design process where material artefacts play an experiential role

3.1 Exploration

From our fieldwork, we observed that design practitioners take into account workplace artefacts, socio-cultural artefacts (within domestic settings) and the life cycle of these artefacts. These artefacts are already in the environment and the way they are organized, arranged and maintained informs designers about how these are experienced by people. In some cases, user-generated artefacts produced during different design exploration methods such as participatory design or a cultural probes study [10] also inform designers about people's experiences. These artefacts represent and embody users' expressions, performance and reasoning of their everyday life. In the exploration phase, to a certain extent, design practitioners try to develop a sense of empathy with users through these artefacts. These artefacts bring about dialogical effects confirming the physical, emotional and conceptual realities. These artefacts may not be seen as isolated objects indicating aspects of users' experiences but these are evidences of the happenings that are related to social and cultural circumstances.

3.2 Communication

In this phase we observed how material artefacts, that are created by designers as design representations, such as sketches, story-boards, mood-boards, physical models and so on, help in communicating the experiential information within design teams. These artefacts help in building an experiential common-ground in teams. Importantly, material artefacts such as physical models allow the designers' direct and bodily engagement and hence broaden communicative resources by evoking sensory experiences. The multi-modality and ability to support and convey information through all senses, makes the use of an artefact experientially rich [15]. In the case of joint design activities, co-workers do not just interact with these artefacts when they are designing, they actually get the feeling and experience of each other's activities through these artefacts. This really helps in the process of collaborative design in which the designers are always in search of new, creative and inspirational ideas. The communication channels that are established by these multi-modal artefacts go beyond facilitating and satisfying basic task-oriented activities.

To an extent, as we observed, the whole design practice progresses through the use and manipulation of these representations and through iterative refinements of both the conceptual and physical designs of products being designed.

3.3 Use

This is the phase where designers try to develop a better understanding of what it is really like to use the products and services that they have collaboratively designed. They come up with several versions and low and high -tech prototypes of their envisioned system and try to use and test their system themselves or they invite prospective users to use the system in their natural environment. For designers, the goal is to convey a specific type of experience through the use of the artefacts they have designed.

In our fieldwork we observed that designers needed to have quick feedback on their designs. There are two ways of achieving this. First, designers interact with each other and try to use and observe the initial experiential effects of their products. This obviously happens in an informal way. In the next step, designers go to their potential users, and ask them to use the system. Trying to maintain the integrity of experience is priority here. However, the experience of the product in the current situation also adds to the overall quality of use. A final system evolves during an iterative process where designers experiment first with low-fidelity artefacts and later with functional prototypes to collect feedback on the user-experience.

4. EXPERIENTIAL PRACTICES THROUGH ARTEFACTS

The analysis of our ethnographic data leads to a rich set of experiential practices that designers apply in their everyday design work. We will present our results as examples of experiential practices utilized by designers as we explored these from our fieldwork. We will discuss how material artefacts play a role in supporting these experiential practices. We believe that these practices are not specific to the environment that we studied but can be seen very commonly in other creative industries as well.

4.1 Evocative Workplaces

One of the most telling aspects of designers' work is the way they organize and personalize their working space. A designers' workplace is an important experiential aspect of their everyday work and plays an important role in designers' performance and creativity [30]. Designers keep sketches, drawings, pictures, models and other relevant things around their working space in a way that constantly informs and inspires their design work. To a great extent, their work was visible from their workplaces even when they were not present (figure 2). As one of the designers commented, *"the space allows me to organize my work and get reminded what I am doing daily. Also for the purpose of communicating with my peers I can very easily show what I am doing."* As can be seen in figure 2, these artefacts are indicative of different phases of the design process, the current state, future planning, and so on. Another designer commented, *"depending on the phase of the project, I arrange my surroundings. It's important for me to have these artefacts around so that I can register where I am at in the project"*. So, these design artefacts were also the markers for reminding.



Figure 2: Some example workplaces at a design department.

The construction of these evocative workplaces was not only about organizing and accounting for different design projects, it was also about developing new ideas, inspiration and creative thinking. A designer commented, *"Normally within a project I need a strong foundation to start with. So, when I am communicating my ideas I need to have several different aspects about my design. Because when the foundation is strong it helps in convincing people. You can't just make a nice, beautiful product and not show the foundation and strong building blocks of it. These visual objects around me show my foundational work and work as strong building blocks."*

Within our exploration we also aimed at getting an understanding of designers' rationale behind their workplace arrangements. As one designer suggested, *"I normally try to visualize all the material and data that I collected from my user studies and try to find out patterns and explore design opportunities from this data. I then make my own sketches and models and keep all these in a way that can help me find out new ideas"*.

Clearly, each designer is unique and the ways in which their workplaces are arranged also differ. Some are socially organized and some are individually organized. Importantly, most of these workplaces have an experiential characteristic. In an example of an individually organized workplace, a designer had organized his workplace by sticking different images on two walls of his office. One of the walls was more or less static and the other was dynamic – in a sense that its contents were changed over time. The dynamic wall had information about the current projects and the arrangement of these items was messy. In addition, he kept documents about his plans within projects. On the other hand, the static wall had artefacts ranging from inspirational source, to information about successful projects – representing more a portfolio-type appearance summarizing the designer's interests and achievements. So, the aspect that we are referring to here is portability and flexibility of these material artefacts that help designers to personalize their work environment. Several of the design students shared co-located or close proximity work spaces. In this case, the way the work spaces are organized becomes a 'joint effort'. Involved individuals select the kind of artefacts they want to keep in the common space and the way to arrange these. Especially when they are working on a common project this helps in improving their collaboration and developing better design ideas.

4.2 Exploitation of Material Richness

The central goal of design is *'the conception and realization of new things'* [7]. Designers continuously make use of the richness

of material qualities of different artefacts before arriving at the final version of their product. The material richness carries substantial experiential effects and is not only observable in the final product but also within different design representations that designers create during their practice. Figure 3 shows an example of the material richness exploited by a student. ‘Afterlife object’ is a lighting system that preserves the uniqueness of a person by representing his/her unique DNA patterns through dynamically generated crystals on its top surface.



Figure 3: Afterlife object: An experiential system that preserves the uniqueness of the body of the loved one. (Photo courtesy of Jan van der Asdonk)

According to the design student, this device is a new way of preserving the unique body of a loved one. Connecting a person’s unique DNA patterns with the growth patterns of a specific type of crystals represents that something of the person is still with his/her family members. The quality and details of the product carry a lot of emotional and personal significance. The shape of the product is based on the Shinto religion. It is like a holy object that should not be held by hands, hence is made as a square (and not round) – preserving its ‘reservedness’ and ‘importance’. Its external body uses the rare African Bubinga wood. When somebody stands close to it, the device lights up and the crystal at the top surface develops a specific pattern. The object shows an afterlife of a person. The variety of materials used in this object – crystal, wood, glass, light, and so on shows the material richness that is exploited by a designer to evoke specific experiences in people.

As we mentioned, the richness of materiality is also exploited at different stages of design. We observed that material richness is utilized for exploring and playing in the design space, for externalizing design ideas and for establishing communication with different stake-holders of the design project. The ‘exploration’ aspect of material artefacts will be discussed in detail in section 4.5. We will focus on the other two aspects here.

We observed that different material qualities are used for different ‘design representations’. Each design representation has its own advantages and disadvantages. There are lots of materials that have their own ideal use, so depending on the situation and stage of the design process designers use the right material, the right techniques and the right approach. As one designer commented, “sometimes, a sketch could be enough to express an idea. But when you want to express behavior or certain attributes, for example, “sticky”, you have to be able to feel that. These physical models can be very easily made to express such behaviors.” Another designer suggested, “I am not good at drawing, so I don’t

sketch much. I am better at making physical models. You can touch it, feel it, try it and get a first impression of how your product will be like.”

There were various preferences in these physical models. As can be seen in figure 4, some designers may try a different range of physical models using for example, clay, foam, wood or plastic. A designer suggested, “I have been a fan of MDF wood. It is solid but at the same time you can mold it in different shapes and sizes and it feels heavy and beefy. When some products are made from solid materials, they are perceived as real products, like the remote control of the BNO television. When a prototype is light it may not be perceived a serious one.” These types of external representations help designers to establish a creative sensibility. For example, sometimes sketching is used for visualizing a designer’s thinking as it stimulates designers’ creativity not only within their head but also with their hands. As one designer commented, “Sometimes it is also useful to get something out of your head (externalize the ideas). When I have a lot of ideas and I know that some of these are not good, I just try to make a sketch of all of them and so that even some less important ideas are stored somewhere. I think it’s a good thing that it gets me going.”



Figure 4: A set of physical models seen at the desk in a design studio.

Another use of design representation is to establish communication among peers. The sketches and models that designers develop serve as a communication tool in the design team. Also, because a part of what we studied was an academic environment, it was very important for the design students to showcase their thoughts and ideas and make them visual, not only for themselves but also for other people to show what they were doing. Some of these students did work with clients and for them it was very important to be able to communicate their design ideas. One of the students commented, “an advantage of sketching is that if I am in a meeting with a client and I can quickly show my ideas to them then, so it is very powerful in communication.” Besides just using words, physical models help designers to quickly show their clients the prototypes and models and issues that are very specific to actions and interaction. And the more examples of these external representations they have, the more useful it would be for communication with the clients.

4.3 Creative Social Practices

Designers apply some innovative and creative social approaches to experientialize the design of their products. What this shows is that designers do not work in an orderly fashion and they are not task-oriented. During the interview session, we asked designers if they use any check-lists, protocols or guidelines while designing their products. Strikingly none of the designers had a pre-defined way of working. According to them, since their design projects have a large diversity, ranging from designing a postcard to

intelligent products and from designing a tooth-brush to automobile instruments, applying a formal and pre-specified design approach is not desirable.

Different material artefacts play a role in supporting creative social practices of designers. Designers use different participatory methods, generative tools, observation methods with their users and clients and use different brainstorming and discussion techniques amongst themselves in their design processes. The social processes that they apply help them to construct new design ideas.

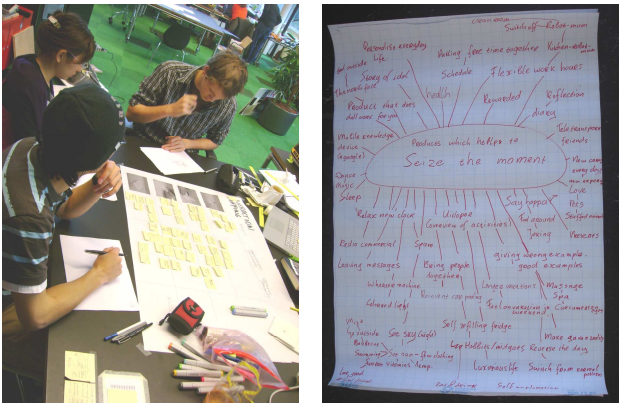


Figure 5: Design students brainstorming at a table and a large sheet with brainstormed information (photo courtesy of Connie Golsteijn).

Designers use different brainstorming techniques (figure 5) at different stages of their design process. For example, at an early stage of design, techniques such as keyword generation, word-associations, and sketching ideas on a large sheet of paper are used to get a broader perspective on design. Whereas during the concept development stage, techniques such as interaction mapping, role-playing or theatre techniques are used to develop behavioral mechanisms in the product.



Figure 6: An example of drawing together on a large sheet of paper.

The most important aspect of these kinds of social practices is that discussions within a design team help to get a better perspective and refinement of the original idea. As a design student suggested, *"I prefer working in teams. While working in a team you can have an exchange of ideas and concept and also of each others' feelings about the design. You can build on each other's ideas and that gives a big advantage."* Influencing each other's work is also an important aspect. As can be seen in figure 6,

designers are working on a large sheet of paper. In this case working in a very close proximity not only helps them talk and see each other's work but also allows learning, adapting and improving on their own work. As one of the design researchers commented that *"it is always an iterative process of creating and reflecting on it. By sitting close to each other and explaining ideas through drawing you can design together and co-reflect on your work."*

In dealing with their users and clients it is important that designers develop empathy with them. Clearly, it is not just about collecting data as a set of requirements and direct observations of users but it facilitates going much deeper into understanding users' experiences. In cases where designers cannot easily collect information from users, they try to use innovative methods amongst themselves. One of the design researchers commented, *"For designing for elderly, we asked some of our undergraduate and graduate students to understand what life is like as 80+ years-old – what we call geriatric sensitivity training. By limiting students' physical and sensorial capabilities, they were asked to perform very generic activities. This lead to an empathy about the eye-sight, movements, and range of motion of the elderly. When students developed this type of understanding, it allowed them to look through things more critically, they could deal with questions in a better way."* In a different example some of the design students attempted to design for people with sleeping disorders by not sleeping for 2 nights themselves and getting a feeling of what it is like to be really tired and still have to finish your everyday things.

4.4 Ephemeral Collaborations

One of the striking aspects that we observed in the design studio was the informality and ephemerality of the way design students communicated and collaborated with each other. This was certainly not considered unusual; in fact this was expected from the students. It was preferred that students would not just sit-down and design all their products on their own. The students would intentionally move around, change the location of their work, create new collaborative spaces, play with different things in the studio, and so on. This is clearly not what we see in other, especially the more formal, work-environments.



Figure 7: Ephemeral meeting places, full of sketches, post-it notes and other artefacts.

As a result of this kind of practices designers develop their own ephemeral environments as can be seen in the above two examples in figure 7. The advantages of these kind of practices by designers are a) this allows them to communicate in close spatial proximity and hence make the information publicly available to all the members of the design team and establishes common-ground in the team; and, b) it provides personalization and flexibility in a sense that it can change the look and shape of the collaborative work environment. These kinds of ephemeral

practices support designers' creativity, innovative thinking and comprehensibility.

4.5 Exploring & Playing

Before arriving at a concrete design idea, designers go through innovative and iterative cycles of exploration. Designers explore new ideas and concepts at different stages of their design cycle using different material artefacts such as sketches, mock-ups, models, working prototypes and so on. As one designer commented, "in order to make design decisions you need to do explorations and for that you need to make different levels of prototypes". These explorations may not necessarily be about the products themselves but about the interaction and expression that designers want to communicate through the products. These explorations can be simple, e.g. sliding, rotating, tilting, and stretching mechanisms that could be incorporated in a product.

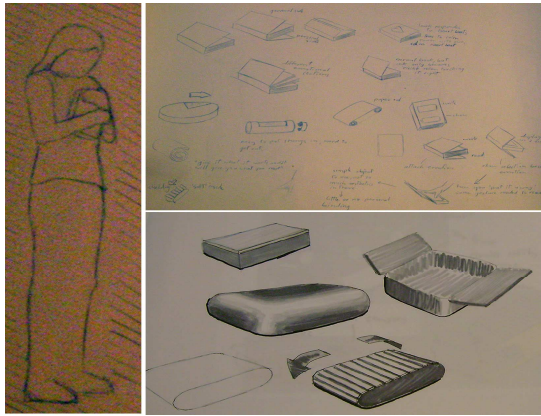


Figure 8: A set of sketches of an interactive diary concept developed by a designer for exploring emotional interactions.

The process of exploring and playing with material artefacts was continuously present and seen throughout the design of products. It covers a broad category of design activities: from very early during the brainstorming session, through developing interaction mechanisms, and designing concepts to evaluating the final prototype. We observed that designers' decisions to choose different design representations and materials for their design explorations were heavily based on these design stages. As one designer suggested: "I start with sketches and doodles, my room is filled with these doodles, and eventually I try making detailed sketches, and then foam models and wood models. So, the process is like starting from 2-D and then make it 3-D and give more details over and over." We observed that the designer's selection of representations utilizing different material artefacts was based on their own interests and choices and the adequacy and appropriateness of their design representations. One designer suggested that, "the way I go about developing a new concept is starting very broadly and narrow it down to a specific idea." This designer preferred sketching as a way of exploring new ideas. Some of the example sketches related to his work are presented in figure 8. The sketches show that he tried to convey experiential, emotional and sentimental aspects through a set of sketch based representations. He commented: "Sketching could be a very quick and inexpensive way of exploring forms and interaction mechanisms that you want to use in your product."

Some of the designers choose other ways to explore new ideas utilizing material artefacts such as cardboard models and wood

models. Creating design models in different forms and textures allows designers to get a feel of their products. A physical model allows designers to extend their mental conceptualization of their product to a sensory one. One designer, by showing a wood model in his hands, comments: "I am not that good in drawing, so I prefer making 3D quick-&-dirty models. This kind of model can provide the feeling of vibrations and elastic effects through the sound, movements and other behaviors. With this you can communicate so much to others and also test your concept at the same time. And through that cycle of talking to others and playing with this object you get new ideas or even strengthen your original idea."

We observed that there are things that designers cannot easily envision through drawing or sketching. They have to practically apply their ideas in different forms of prototypes. We will give an example of utilizing light and smoke in product design. A set of explorations from one designer are shown in figure 9.

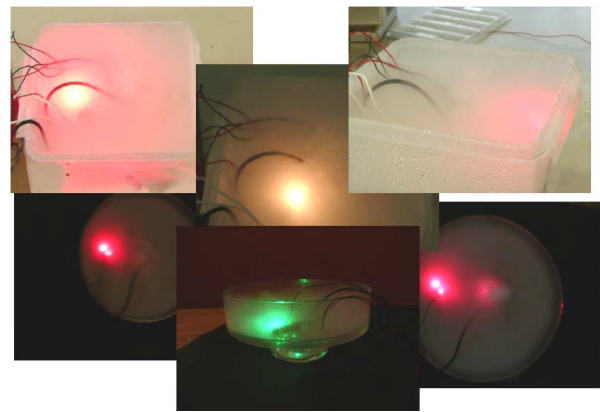


Figure 9: Playing and exploring with smoke and lights to develop new ideas. (Photo courtesy of Rob Tieben)

This designer explains that "there are certain things that you cannot envision in a normal situation, things like "smoke". So in order to understand the behavior and interaction with smoke and utilizing it into design you have to build some things and play with it." By joining the exploration of smoke with different kinds of lights, the designer explains, "even by playing with a light I can get several new ideas about new ways of interacting with lights, like blinking, fading, making patterns, so expressing new behaviors through the use of lights and different colors of lights. This opens up my visualization skills and provides new spaces for design. In this case if I just sketch this smoke with light, I wouldn't get that feeling. Here you can play with your hands, move the smoke around, this is a very different kind of design expression and gives me different feeling."

4.6 Reflective Practices

Another experiential aspect of designers' everyday work is the way they reflect on their products and different design representations. A tendency to *reflect-in-action* [23] during the course of actions could bring a capacity to designers to cope with the unique, uncertain, and conflicting situations of their design practice.

Normally, designers do not judge design work using any valuation matrix (e.g. 8 out of 10). We observed that designers use group reflection and self reflection practices to analyze and evaluate their design work. Figure 10 shows a group reflection

session during a teaching course. Here the students try to criticize each other's sketches in a constructive way.



Figure 10: Design students reflecting on each other's sketches in a group reflection session.

Usually, while visualizing and applying their thoughts and ideas, it is important for designers to see how others understand their ideas. Sometimes product ideas are intentionally made incomplete, but are kept open so that designers can gather creative ideas from others. As one of the design researchers suggested, *"we don't want to deliver a concrete product idea, we always want to be flexible in our design to better understand each other and also take into account what the clients want."* During group reflections even a 'stupid' idea or suggestion could invoke inspiration and show designers new roots to their designs. Supporting this kind of group reflection methods, one of the design students commented that, *"if it is only about the functionality then I can test it by myself, its very easy. But when the product is meant for supporting a specific kind of experience like establishing balance in users' everyday lives then this has to be tested and discussed with others in a rigorous manner."* In addition to providing constructive criticisms designers use techniques to invoke group reflections. One such method that was mentioned was making a Mood-Movie as a reflective statement. In this case designers make a short video story about their work, ideas and observations and within the group other members can reflect and discuss on it.

Self reflection is also a technique that is much emphasized within the educational environment that we studied. We observed several ways for self-reflecting. One designer suggested, *"I reflect on my work at different levels. I think about the steps I have taken. And ask myself, were these the right ones? Then I reflect on the research I have done. And try to evaluate my work based on all these."* There were, in fact, some refined formal techniques for self reflection. All the designers and design students keep a sketchbook as a storage point for their work and a means for reflecting on their work. Several designers record their design process in their sketchbooks. So when they get stuck or have problems they can come back to this sketchbook and rethink the process they used, try to figure out where they might have taken a wrong decision or identify things that might have been forgotten.

5. DISCUSSION & IMPLICATIONS FOR DESIGN

In the last decade, there has been a growing importance of user-experience and other subjective aspects in the design of interactive technologies. Recent research in HCI [5, 8, 18]

suggests that the design space should be made open to these non-instrumental and subjective qualities of interaction. Additionally, because of the growing ubiquitous computing [32] push, technologies are becoming a part of people's everyday lives. This requires HCI practitioners to understand users' socio-cultural contexts through creative approaches and understand people's attitudes, aspirations, contexts and experiences. Echoing Rogers's [22] research agenda for *designing ubiquitous technologies for engaging user experiences*, we believe that by understanding industrial designers' experiential practices we can better support their practices by designing appropriate technologies.

Our ethnomethodologically informed fieldwork in two industrial design departments show that material artefacts such as sketches, drawings, physical models, prototypes and so on play an experiential role at three different levels: exploration, communication and use. Clearly, in an iterative design process there are no definitive distinctions between these levels. Their materiality, use and different manifestations add richness and quality in designers' working practices.

Experiential practices are not a new phenomenon for industrial designers. In fact these practices are inherent to their everyday way of working. Practices such as creating evocative workspaces (full of inspirational design materials), exploiting material richness, creative and ephemeral collaborations with co-workers, exploring and playing with material artefacts and reflecting on each other's work are not uncommon in the domain of industrial design. We term these as experiential design practices because these are not necessarily intended towards solving any design problem. Additionally, we also want to suggest that this is definitely not a complete list of experiential practices and we present these practices merely as examples that can inform the development of future design tools. From our results we suggest that having an evocative workplace, for example, utilizing different design-related artefacts is not just a practice for reminding or easing the communication difficulties. This practice helps designers' imagination, improves their foundations and building-blocks and helps in generating innovative ideas. The expressions of different design artefacts and the way they come about in designers' everyday work have an aesthetic quality – as *'being present'* [11] in designers' work. Similarly, other experiential practices such as exploiting material richness, applying creative social practices, ephemeral collaborations, exploring and playing with artefacts and applying reflective practices also involve a use of design artefacts that is not purely for instrumental purposes. Especially, artefacts such as design sketches are shown to be valuable in supporting most of these experiential practices. As Baskinger [2] suggests, design sketches are useful not only to develop a design idea, they are used for envisioning, recording, narrating ideas, sharing and reflecting both at individual level and at social levels.

What has been presented in the previous section is a list of examples of designers' current experiential practices supported by material artefacts. Although our analysis only represents one creative industry – industrial design, we believe that these practices may not be uncommon in other related creative industries. These rich design practices provide indications about how new technologies should be designed. Based on the ethnographic data, we suggest the following implications to design collaborative system for industrial designers. We aim to highlight some specific areas where new collaborative

technologies can be developed to fit designers' everyday social practices.

5.1 Encourage Creative Explorations

We observed that designers spend a considerable amount of time in exploring new ideas and concepts by utilizing different techniques and design representations. In a co-located situation such as a design studio, spatiality and visibility play an important role to support creative explorations. To encourage creative explorations within a geographically dispersed design team, we suggest looking beyond desktop-based applications. Media spaces [3] and other related collaborative environments allow audio-video communication, through mainly representing people's faces on the screen. In fact, in the case of collaborative design, designers need to be able to access the spatial aspects as well as different design materials and artefacts involved in a design project. One way of aiming at collaborative creativity is by embedding computation to physical objects and their modalities (augmented reality and ubiquitous computing) or using computation to connect to the surface of physical media using projection technologies.

There is a plethora of multimodal and heterogeneous artefacts and tools designers use based on the needs, preferences and the stage of design. Our fieldwork suggests that for creative explorations there is a need for an infrastructure that allows designers to capture, integrate, and arrange these artefacts. Obviously, this should be done in line with the current practices of designers. There are well developed examples in this domain focusing on specific aspects of design processes, for example interfaces for collaborative drawings [4, 28], for creating architecture plans [29] and for making clay models [19]. These are some good examples of supporting design explorations, however, we need more work to support a larger array of design practices. In some cases, it might also be important to see and understand where digitization of physical artefacts (such as sketches) will be beneficial.

5.2 Allow Social Flexibility

For a remotely located design team, a new technology must provide social flexibility. The technology should not impose tedious and unfamiliar practices for using it; instead it should be smoothly integrated into designers' everyday work. Different projects require designers to use different collaborative approaches and methods. Additionally, they do not follow strict protocols or design guidelines. To incorporate this heterogeneity and informality into the design of a collaborative system can be a difficult issue.

In particular, we believe that social flexibility should be provided by understanding how collaborations are supported by the properties of different material artefacts. When designers communicate with each other, design artefacts themselves become a source as well as the mediator of information. In fact, material artefacts, as we have shown in the paper, play a crucial role in supporting collaboration. While working with different material artefacts, designers tend to go back and forth between different media (e.g. from sketches to physical models and back to sketches). Both the physicality and multimodality of these artefacts become crucial here. In the remote collaborative situation, we need to be able to augment these artefacts in such a way that designers are collaboratively able to "connect" these artefacts to establish their communications. There is a value in associating and connecting different design artefacts.

Technological restrictions currently mean that there is little opportunity to associate the digital and physical, but there is no reason to suppose that opening up that possibility would not add value. For example, a card-board model of a design idea can be made richer if it can be linked to other representations such as sketches, story-boards and so on. Similarly, with a new technology co-designers should be able to attach valuable annotations and background work to these artefacts. With a large heterogeneity, some of the artefacts should be provided specific representation and interaction styles not only because of their multi-modal nature but to support the kind of expression and annotations they carry.

Most of the collaborative systems to support design work have focused on the real-time communications by supporting limited modalities (mainly visual and speech). In order for designers to reflect on their work, we need to provide a platform where designers can constructively criticize and build on each other's work. For this, designers need more than an online chat system. An asynchronous way of communicating and reflecting on each other's work could also be considered as it may allow more time and space for the designers.

6. CONCLUSIONS

We believe that this paper contributes to the HCI and CSCW communities in two ways. First, it shows that in order to develop technologies for creative industries such as industrial design, non-instrumental and experiential aspects are essential in supporting creativity and innovation. Secondly, the paper shows that material artefacts help in supporting and establishing experiential practices, hence play an experiential role for understanding cooperative work.

The experiential design practices that are discussed here are often neglected for the sake of collecting instrumental and practical requirements. As we have shown in this paper, these experiential practices are the part-and-parcel of design practices and other creative industries in general. In fact, practices like exploring and playing with artefacts, exploiting material richness, and creative social and ephemeral collaborations seem to yield unique results for design. Surely, instrumental needs such as providing quick updates, showing work-in-progress, real-time sharing of information, 'shared working space', and so on (as advocated in [4]) are still important for establishing systematic communication between the team members. But the experiential practices discussed here are about supporting creativity and innovative processes of designers. Combining both, the instrumental, and the non-instrumental aspects, will lead to a complete and holistic understanding about how we can provide technological support for cooperative design.

Because of the growing availability of ubiquitous computing and augmented reality systems, it is opportune to consider the experiential aspects related to material artefacts. Our work shows that physical media and artefacts used in design practices are versatile and have unique qualitative and sensorial richness. Our work echoes studies such as Sellen and Harper's [25] work on the use of paper documents in organizations and Jacucci and Wagner's [15] fieldwork on architectural design students. We believe it is time for HCI and CSCW practitioners to understand and appreciate the role of artefacts to ensure that these roles are embodied within the systems that they are developing.

7. ACKNOWLEDGMENTS

This work is supported by the European IST Programme Project AMIDA (FP6-0033812). This paper only reflects the authors' views and funding agencies are not liable for any use that may be made of the information contained herein. We thank Kees Overbeeke, Caroline Hummels, Mark Baskinger, Mascha van der Voort and the master's students of Industrial Design at Technical University of Eindhoven and University of Twente for participating in our study. Thanks also to Lynn Packwood for proof reading.

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