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### MAPS FOR DESIGN REFLECTION

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# MAPS FOR DESIGN REFLECTION

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In this paper the authors introduce, apply, and discuss a set of design artefacts called *maps*, intended to support design researchers in capturing, analysing, and reflecting upon design processes. The maps focus on reflection with regard to the role of sources of inspiration and design materials in the emergence and transformation of design ideas. The paper revolves around a specific case, the design of media façades – i.e. displays that are an integrated part of a building's façade – as part of the development of material for a bid in an architectural competition for a new modern art museum in Warsaw, Poland. They discuss their findings from using the maps for design reflection in this case, with a particular focus on the importance of employing artefacts to support design reflection.

**Keywords:** design process, reflection, sources of inspiration, design materials, design idea, media façades

For interaction design researchers, the emergence of design ideas from sources of inspiration through a series of experiments that transform design ideas is central to research inquiries. However, there is a lack of tools that support researchers in documenting and reflecting on these elements and their interrelations. In this paper, we present and discuss three types of maps intended to support reflection and research into design processes. The contributions of this paper are, first and foremost, the presentation of the maps as concrete design artefacts for researchers interested in exploring how design processes unfold, and, second, a presentation, analysis, and discussion of a specific case in which we delve into the ways maps can offer insights into the transformations that design ideas undergo, as they are transformed from initial sources of inspiration to well-rounded design concepts, through design experiments using a repertoire of design materials.

Our development of the maps for design reflection is inspired by Lanzara and Mathiasen's (1984) work on mapping design processes. Whereas Lanzara and Mathiasen primarily address issues related to management of design processes, this paper is aimed at *design researchers*, and focuses on reflection on design practice, particularly with respect to the role of sources of inspiration and design materials in the emergence of design ideas.

The research area of interactive systems design includes studies of interactive systems, new design tools and techniques, and case studies of design practice. Our contribution may be regarded as a response to the call for research into the practice of design, put forward by Wakkary (2004), who states that "it is by far more common to record interactions and real-time observations of 'users' but not practitioners" (Wakkary, 2004, p. 443). Our approach can be construed as one way of conducting *research through design* (see Zimmerman et al., 2007): As design researchers, we

have taken advantage of our engagement in specific design practice, to explore and develop approaches to reflection on critical aspects of the design process. With reference to the design theory and HCI research taxonomies proposed by Atwood et al. (2002), and Wanie et al. (2006), our work is rooted in the participatory design tradition, and theoretically based on Schön's (1983, 1988, 1991, 1992; Schön & Bennett 1996) pragmatic design theory.

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The specific case that provides the fuel for researching design practice concerns our involvement with BIG (Bjarke Ingels Group, a Danish architectural group), in the development of material for a bid in an architectural competition for a new modern art museum in Warsaw, Poland. As design researchers at CAVI (the Centre for Advanced Visualization and Interaction, at the University of Aarhus), we (the authors) became engaged in the process due to CAVI and BIG's mutual interest in the development of innovative ways of integrating interactive media façades as part of the proposal for the new museum. *Media façades* is the general term for incorporating displays that are an integrated part of a building façade (ag4, 2006), and constitute a fast-growing business, primarily due to the increase in quality and a drop in the cost of light emitting diode (LED) technology. The content may range from pure artistic expression, to informative art and entertainment, and company and brand communication. In the present instance, we were particularly interested in going beyond LED displays, to explore the potential of using unconventional materials for the implementation of media façades, and ended up using thermo-chromatic concrete (TCC), a material that enables a concrete façade to become a display in its own right.

TCC was originally invented by Glaister, Mehin, and Rosén (<http://www.chromastone.com>), and utilizes a current applied to a heating element placed inside the concrete to make the temperature rise, causing it to then change colour due to the presence of a heat-sensitive ink mixed into ordinary concrete. Available colour changes are black to white,

red to white, and grey to white, but more colour options are being developed. The nature of the material makes it best suited to low-resolution displays (see Figure 1). As we shall elaborate later, TCC turned out to play a key role in our collaboration with BIG, from this point onwards.

As design researchers, we have used the specific case introduced above as a platform for exploring new ways of making sense of design situations. In the collaborative process with BIG, we have thus been acting both as researchers, in having the aforementioned agenda of exploring design reflection, and as designers, in actively partaking in the development of the museum proposal. Specifically, our contribution to the collaboration was the design of interactive digital elements in the museum building, whereas BIG was responsible for the general architectural concept and structure of the museum. Our work within the interaction design group was largely autonomous, though coordinated with BIG through meetings and ongoing discussions. This intimate knowledge of the design process supported the development of detailed maps for design reflection in our simultaneous and subsequent work as design researchers, in which we have explored the unfolding of the design process.

This paper is structured so that in section 1 we first outline the background for developing the three kinds of maps – Overview, Strand, and Focal Maps – and the influences of related academic work on the topics of sources of inspiration, design materials, experimental design, and tools for process mapping. This is followed, in section 2, by a detailed presenta-

tion of the maps. To give a comprehensive account of their support of design reflection, we present the specific case of developing the design proposal for the Warsaw MoMA, in sections 3, 4, and 5. In these sections, we present in-depth uses of each of the types of maps, coupled with our findings and analysis of their use. We then present our conclusions, and discuss further perspectives on using Overview, Strand, and Focal Maps in combination, in section 6.

## Background

According to Schön (1983, p. 135), design is a reflective conversation with materials, wherein the designer works with different media or materials, and experiments with various aspects of the design. There is a continuous dialogue between the designer and the materials, causing him/her to apprehend unanticipated problems and potentials in terms of a system of implications for further moves (Schön, 1983, p. 101). Rather than looking for standard solutions, the designer sees the situation as something already present in his/her repertoire of paradigm cases or prototypes, despite which he/she manages to make something new by making experimental moves, which may result in something that goes beyond his/her initial expectations. Schön's design theory distinguishes between reflection-in-action and reflection-on-action. Reflection-in-action is the kind of thinking that takes place as an integrated part of the action, and which may affect the completion of the action itself. Reflection-on-action is the sort of thinking that occurs after the completion of an

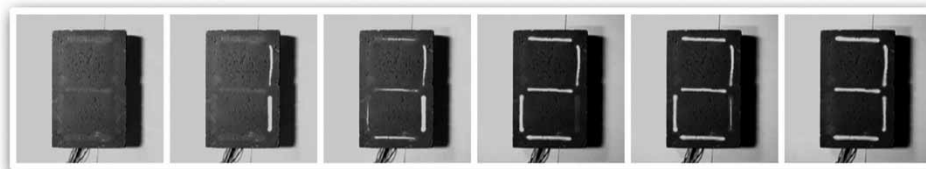


Figure 1. Thermo-chromatic concrete.

action, and by definition is excluded from affecting the action.

Whereas Schön is primarily concerned with the kind of reflection-on-action conducted by *design practitioners*, we are interested in supporting *design researchers'* reflection on design activities. Our research focus is strongly connected to Schön's design theory, with a particular focus on the emergence of ideas from sources of inspirations arising through a series of experiments with various kinds of design materials.

In addition to Schön (1983), several researchers, including Sanders (2005), have addressed how sources of inspiration play an important role in the emergence of design ideas. In the area of information systems design, Madsen (1994) has explored how metaphors may shed new light on the ways in which information technology might be used, by seeing a domain of applications as something else. Lervig and Madsen (2003) addressed the ways in which sources of inspiration serve as jumping-off points for work in a design project, when digital artists and designers worked together. Sanders (2005) has argued that inspiration plays a prominent role in experience design. Consciously looking for inspiration is part of the innovation strategy discussed by Kelly (2001, p. 280), and Foster (1996) suggests doing things to which you are unaccustomed, as potential sources of inspiration. An essential point made by Foster (1996, p. 114) is that if generating new ideas primarily consists of combining old elements, a thorough familiarity with the old elements is essential.

Following Schön's pragmatist understanding of the design situation as a dialogue between designer and materials (see Schön, 1983, p. 135 and Schön & Bennett, 1996), the notion of design materials is of central concern in our inquiries. In reflective practice, design experiments often imply the use of materials through which potential design moves are shaped, evaluated, and put into the world. Such

representations by use of design materials can highly influence both our performance and understanding, as is extensively demonstrated by Klemmer et al. (2006). To the extent that design materials extend our cognitive practice, we may think of them as *inquiring materials*, as proposed by Gedenryd (1998, p. 149): "An inquiring material then, like an inquiring action, does not function as an *end* product of design, but as a *means for* inquiry that design is." Design materials can be physical materials such as pen and paper for sketches, and foam core board for mock-ups, but they can also be digital materials, such as 3D models and virtual video prototypes (see, for instance, Halskov & Nielsen, 2006).

To support researchers' reflection on design, we propose a set of three kinds of artefacts, called maps, which are material tools for recording unfolding design processes. In our mapping of design processes, we have a strong focus on sources of inspiration and the various forms and instantiations of design ideas, and how they use a repertoire of design materials, manifested as written memos, as sketches on paper, as 3D renderings, as physical models, etc.

As mentioned in the introduction, our maps for design researchers' reflection on design activities are inspired by the maps proposed by Lanzara and Mathiasen (1984), who have proposed four different maps, which may help *design practitioners* make sense of the situations in which they are involved (see also Andersen et al. 1990). Lanzara and Mathiasen focus on management issues, and distinguish between four kinds of maps: diagnostic maps, ecological maps, virtual maps, and historical maps. A *diagnostic map* relates perceived problems in a project situation to their sources, as well as the general conditions of the project. An *ecological map* relates the situation to the conditions that shape the circumstances in which people are acting. *Virtual maps* address possible future situations. Finally, *historical maps* organize past experi-

ences in a time sequence, by focusing on the dynamic interplay between actions, conditions, events, and issues.

Based on Schön's (1983 p. 54) notion of reflection-in-action, Jepsen et al. (1989) have suggested the use of diaries as tools for reflection on the progress of a design process, with a particular focus on diaries as media for project management, addressing problems and conflicts related to deviations from plans, but also with an awareness of methods applied, and working habits. Another related use of diaries as media for design reflection has been reported by Pedgley (2007) in the context of physical design, using the design of a polymer acoustic guitar as the main case. In addition to a number of general diary instructions, and a list of good practices in diary writing, Pedgley (2007, p. 473f) provides three types of *pro forma stationery* or templates for end-of-the-day diary writing. For the subsequent analysis of the entries in the diary, Pedgley uses an emergent coding scheme covering a broad range of aspects, including "2D modelling", "Knowledge and values", and "Level of detail reached". In a similar vein, McDonnell et al. (2004) have described how designers can employ video story-making relating to their design work to support critical reflection on design experience beyond reflection-on-action.

The maps for design reflection are related to and inspired by the above-mentioned works; however, the maps contribute to the field of interaction design research by extending the repertoire of design researchers in a number of ways: first, although differing in scope and focus, the related publications generally address tools for *design practitioners*. The maps we present in this paper are, however, intended as tools for *design researchers*. Second, analyses and discussion of design processes in research contributions are most often based on *theories as design artefacts*; for instance, Schön's understanding of design as reflective conversation can serve as theoretical scaffolding for design analyses. The maps presented here can be

construed as *design artefacts in the shape of a set of concrete, tangible tools* that scaffold reflective analyses. In this respect, our approach is inspired by the perspective of distributed cognition (Hutchins, 1995), in that our main approach to mapping and reflecting upon the design process is based on charting the representations present in the design process (e.g. words, text, images, movies, and models) and their transformation and flow. The distributed cognition perspective proposes that cognition and knowledge are situated not solely in the mind of an individual, but rather they are distributed amongst a number of actors, artefacts, and surroundings. Studies of distributed cognition are thus founded in the study of the various representations present in a situation, and the changes they undergo. Our use of maps leads us to propose that the central ideas in a design process are those that are explored through various modes of representation. Subsequently, mapping these representations constitutes a meaningful foundation for design reflection. The maps thus provide researchers with a structured method of identifying and capturing aspects of the design process that may otherwise be overlooked. The use of maps for design research reflection points to the importance of having artefacts to support cognitive processes. This is

the case at two levels: With regard to the events that unfold in a design process, the design representations that emerge (e.g. conceptual sketches, mock-ups, and prototypes) are manifestations and crystallizations of design reflections and moves in action. With regard to design reflection, maps themselves are crystallizations of the design researchers' reflections. As such, the maps can serve as useful boundary objects between researchers and designers, including on those occasions that researchers examine from the outside design processes in which they themselves were not involved.

In the following section, we present three kinds of maps that focus on reflection on design practice, with regard to the role of sources of inspiration and design material in the emergence of design ideas.

### Maps for design reflection

The three types of maps for design reflection we propose are: *Overview*, *Strand*, and *Focal Maps*. Each of these maps highlights different aspects of the design process, and supports analyses of distinct design considerations and moves, as well as overall trends in design processes. The Overview Map provides a comprehensive outline of sources of inspiration and the emergence of the multiplicity of ideas throughout the process, whereas the

Strand Map focuses on the transformation and materialization of the main idea. The Focal Map looks in greater detail into the refinement of ideas through specific design experiments.

### Overview Maps

Overview Maps encapsulate the main elements and trends of an entire design process in a single representation. The map consists of a timeline, along which the emergence and interrelation of conditions, sources of inspiration, and design ideas are mapped (see Figure 2).

For overview purposes, these elements are represented by icons (see Figure 3) representing *words* (i.e. *oral statements*), *text*, *images*, *movies*, and *models*. Specific phases in the process (e.g. field studies and prototype development) may be indicated on the map for a structured overview. Furthermore, an important part of the Overview Map is the pair of lines representing the *design horizon*, that is, the scope of potential design solutions that are considered in the design process. The design horizon often fluctuates throughout a project, as designers move through phases of *divergence* (Löwgren & Stolterman, 2004), when multiple design solutions and moves are explored, and *convergence*, when specific design solutions are

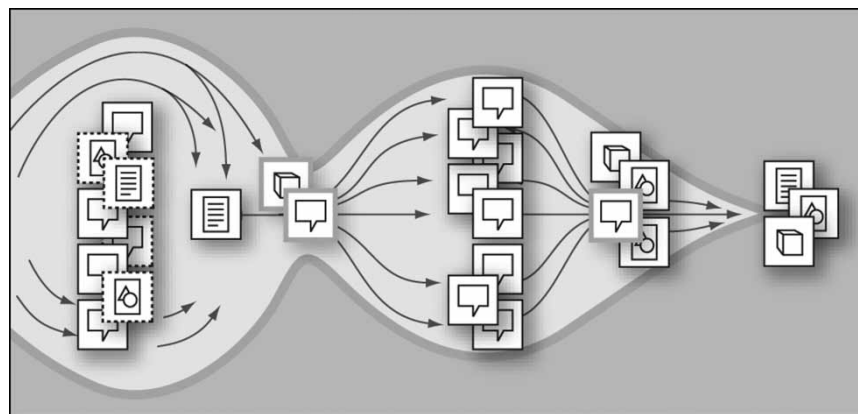


Figure 2. Overview Maps provide an overview of the entire design process.

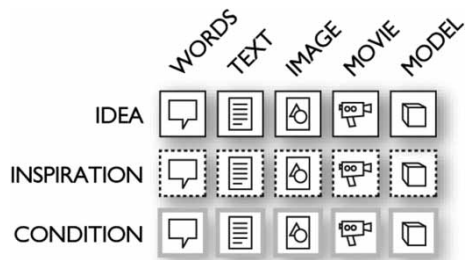


Figure 3. Icons used in the Overview Map.

decided upon or determined by external factors.

Overview Maps first and foremost facilitate a structured overview of the design process as a whole. Used as an analytical tool for finished projects, it affords opportunities for reflection on the flows and trends that have shaped the project, and makes clear the key phases or incidents, for example points in time at which the design horizon changed dramatically. For an example of a complete Overview Map and the reflections it facilitates, see section 3.

#### Strand Maps

Strand Maps represent the emergence, transformation, and concretization of specific strands or threads through a design process (see Figure 4). This allows designers to home in on the emergence and flow of a particular design idea, and analyse the ways in which it has materialized throughout the process. The Strand Map uses the same iconography as an Overview Map, but is more specific about the design materials used in each of the iconographic categories: *words* (referring to oral

statements such as presentations, telephone calls, etc.), *text* (e.g. design documents and memos), *images* (e.g. field study photos and idea visualizations), *movies* (e.g. video prototypes and test videos), and *models* (e.g. mock-ups and prototypes). The icon is supplemented with a larger representation, such as representative text snippets from conversations or documents, a photograph, a screen capture from a movie, or a photograph of a model. The elements are listed in the sequence in which they materialize in the design process.

Strand Maps facilitate reflection on the development of specific concepts or ideas throughout a design process. For example, they may capture the way in which a concept initially emerged as a loose idea in a conversation, was then sketched out on paper, visualized in 3D, mocked-up, prototyped, and finally manufactured as a finished product. This facilitates reflection with regard to the specific transformations and crystallizations of a design idea. For an example of a complete Strand Map and the reflections it facilitates, see section 4.

#### Focal Maps

Focal Maps spotlight specific design experiments within a strand (or at their intersections) in a design process. A Focal Map lists descriptive elements of a situation, namely the *subject* of a design experiment, the *approach* to the subject, and the *outcome* of the inquiry. The descriptive elements each have reflective counterparts, namely their *relevance* to addressing a specific subject, the *rationale* behind the approach chosen, and the *insights* gained from carrying out the inquiry (see Figure 5).

The combination of descriptive and reflective elements prompts reflection on the reasoning underlying specific design moves and experiments, the ways they transform a design idea, and the general insights gained from carrying them out. This may take place immediately after an experiment, when outcomes and insights are considered, or it may take place after a project is completed, in order to delve into situations that, in retrospect, turned out to be crucial to the project. For examples of complete Focal Maps and the reflections they facilitate, see section 5.

As presented above, the three kinds of maps focus on different aspects of the design process (see Figure 6), but share a common concern for the emergence of ideas in the design process. The maps are not to be construed as exhaustive and fully objective representations of a design process; instead, the process of mapping an overview, a strand, or a specific situation is an interpretive act in which reflection on design practice occurs.

#### Overview Map – focusing on sources of inspiration and ideas

In this and the following sections, we offer a reflection on the development of the interactive concepts for BIG's MoMA competition bid, using the Overview, Strand, and Focal Maps. The maps were developed after the design process, in order to facilitate reflection on relations between *sources of inspiration*, *ideas*, *materialization*, and *experiments*. The process was documented through the ongoing use of field notes, video recordings of meetings



Figure 4. Strand Maps represent a specific design strand.

DESCRIPTIVE ELEMENTS	REFLECTIVE ELEMENTS
Subject: What is explored?	Relevance: Why is it explored?
Approach: How is it explored?	Rationale: Why this approach?
Outcome: What is the result?	Insights: What knowledge is gained?

Figure 5. Focal Maps spotlight a specific design situation.

(including transcriptions of selected passages), and the archiving of all design materials in use.

The overview map (Figure 7) is organized according to the eight main activities of the overall process (columns I–VIII in Figure 7), and the numbers 1–9 refer to the Strand map to be addressed in section 4.

#### From inspiration to idea

At the initial meeting (column I in Figure 7), our partners from BIG presented the competition conditions, which addressed not only the museum itself, but also the development of both a square and a park adjacent to the museum. BIG presented volume studies they had conducted, along with sources of inspiration from architectural reference projects, and these constituted the starting points for the

design process, see Figure 8. Various sources of inspiration emerged spontaneously, including TCC. Not all sources of inspiration were systematically documented, but photos and notes document a wide range of sources such as architectural references, various materials such as expanded metal, interactive installations, and, as mentioned, the TCC. By the end of the meeting, the basic idea to be pursued was still vague, but revolved around using digital technologies in transitional areas, rather than in the exhibition space.

After the initial meeting, we decided to continue by using the inspiration card workshop format (see Halskov & Dalsgård, 2006), an approach primarily used in the early stages of a design process, and involving sources of inspiration for narrowing down potential de-

sign ideas. The inspiration card workshop (column III in Figure 7) sparked a number of ideas, such as integrating a navigation system into the architecture, principles for visually connecting the museum with the nearby subway station, and a series of principles for the use of TCC. A few of these were documented as concept posters – though often only in a sketchy way. The use of TCC evoked the interest of the principal architect, in particular, and came to play a key role during our collaboration with BIG, from this point onwards. We take this incident as the point of origin for the Strand Map in section 4. Even though only TCC was chosen to be used in the subsequent process, the Overview Map documents how aspects of other sources of inspiration influenced the use of TCC.

MAP	FOCUS
Overview	Source of inspiration and ideas
Strand	Materialization of ideas
Focal	From experiments to ideas?

Figure 6. The three kinds of maps.

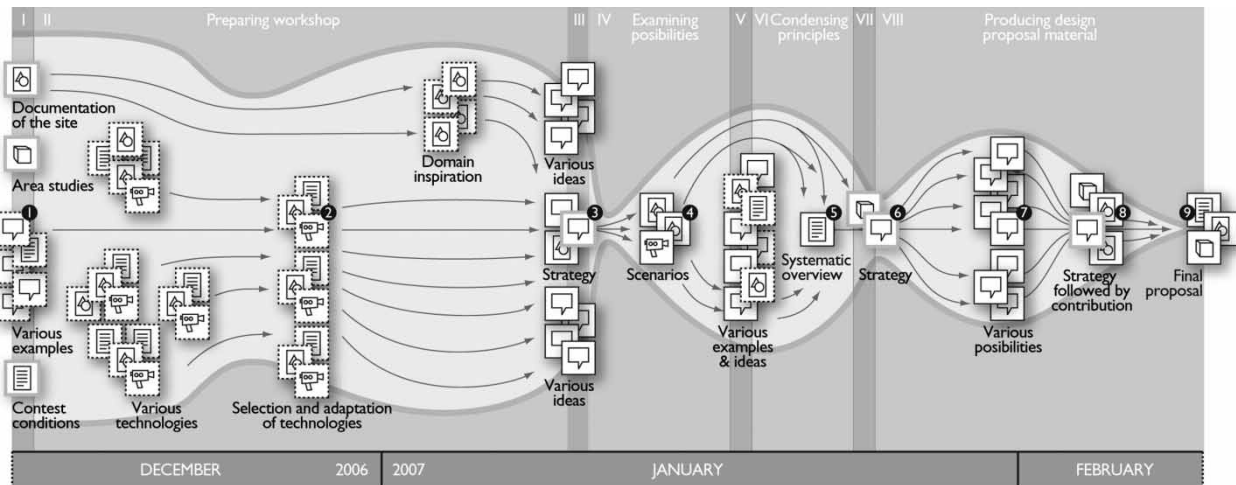


Figure 7. Overview Map of the Warsaw Museum design process, focusing on sources of inspiration and ideas.

After the inspiration card workshop, the decision to use TCC initiated a series of experiments examining the possibilities of this particular material (column IV in Figure 7), and, in order to further explore the potential of the TCC, CAVI organized a workshop with a digital artist (column V in Figure 7). The digital artist brought a number of sources of inspiration from the area of interior design into play, which provided important input to the process, but it was also evident that the huge amount of visual material available was overwhelming. In the subsequent period (column VI in Figure 7) the properties and potentials of the TCC were organized into a

matrix that attempted to structure an overview of the possibilities.

At the last workshop with BIG (column VII in Figure 7) CAVI presented the previously developed visualizations and scenarios, together with the matrix. The meeting was followed by the last phase of the process (column VIII in Figure 7), which started from the conclusions and guidelines agreed upon with BIG, with regard to the possibilities of the matrix. The matrix itself inspired numerous ways of integrating TCC into the building proposal, and also led to discussions about perception, by means of distances and angles in relation to visuals created using TCC,

which in turn led to experiments expounded in the analysis in the Focal Map in section 5.

At the end of the design process, CAVI's final contribution consisted of a *brief description of TCC*: this included the basic premise of using TCC interactively. *Presentation principles*: these consisted of practical considerations regarding TCC content, seen at various distances and from various angles. *Technical references*: these included links to related examples and prototypes. *Proposals for use of TCC in the Warsaw MoMA*: these comprised the primary part of CAVI's contribution, and consisted of three specific ideas for the use of TCC in the MOMA, namely to (1) *integrate visualizations*



Figure 8. Left: The wide range of sources of inspiration and materials. Right: The principal architect refers to an inspiring book to help illustrate various digital projection possibilities.



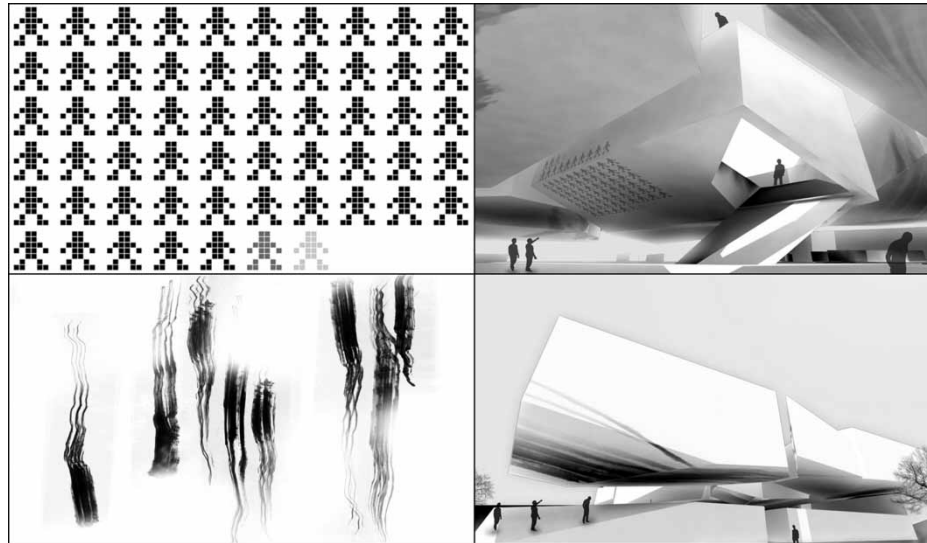


Figure 9. Upper left: Symbolic representation of number of visitors. Upper right: Indication of number of guests in the special section exhibition hall. Lower left:

of building and visitor data such as use statistics, e.g. number of visitors at the present time, most popular exhibits, etc. (see upper left and upper right in Figure 9); (2) peripherally visualize traces of the visitors as lines in the ceiling that reflect visitors' movements through the museum (see lower left and lower right in Figure 9); and (3) present exhibition visuals that employ the façade and the interior walls of the museum to present the current exhibitions.

#### Findings from using the Overview Map

Overview Maps capture and document the complexity of design processes. Although the only in-depth examination in this paper is that of the specific case of the Warsaw MoMA, our experience of numerous other design projects suggests that most have similar or higher levels of complexity. We have found that through the process of mapping out this complexity, the Overview Map serves well as a platform for in-depth analyses of the expanding and converging design horizons throughout projects. By capturing the multitude of sources of inspiration and ideas in the Warsaw MoMA design process, the overview mapping process impli-

cally supported comparison of and reflection on their interrelations and effects on the overall flow of the process, by focusing our attention on the major shifts in the process, and by forcing us to identify critical junctures for in-depth analysis. Thus, the Overview Map has been helpful in the retrospective analysis, not only in capturing and freezing the multitude of sources of inspirations and ideas, but also in documenting unmanageable and intangible elements in an operational and concrete way.

The Overview Map also makes clearer the ways in which sources of inspiration work at different levels. One level is that of the linear strands that come into view during the mapping process (see next section). Some sources of inspiration do not lead to any ideas, but only to strands with dead ends, and others influence other strands, even though they might be dead ends themselves. In this sense, the Overview Map captures a greater richness of a design process as the sum of all sources of inspirations and related ideas than does a traditional focus on the result alone. At an analytical level, although the map can stand

alone as a tool for reflecting on general trends and design horizons, we find that it functions much better if used in conjunction with Strand and Focal Maps.

#### Strand Map – focusing on the materialization of ideas

The Strand Map for TCC in Figure 10 illustrates the way in which the idea of integrating colour-changing concrete into the final building proposal underwent changes, from oral, inspirational input early in the design process, to specific use-scenarios and illustrations in the final proposal. The numbers of the clusters on the map (1–9) refer back to the Overview Map in Figure 7. This specific Strand Map takes off at the beginning of the process, and continues to the end. In relation to our overarching research goal, the Strand Map highlights specific transformations, from the notion of TCC as an abstract source of inspiration, through explorations of various design materials in which the ideas were variously elaborated, up to the final ideas being incorporated into the architectural proposal.



Figure 10. The Strand Map for TCC.

The rationale for focusing on the concept of using thermo-chromatic concrete in this particular Strand Map is straightforward, namely that the TCC technology and potential ways of implementing it in interactive buildings became the crux of most of CAVI's design work from an early stage of the process. Retrospective analysis offers a privileged perspective, with regard to identifying the sources of inspiration that are eventually of most influence in terms of the final result, in that knowing the end result of the process facilitates 'reverse engineering', in which the ideas embedded in the final design can be traced back towards the point at which they first appeared in the design process. Whereas Overview Maps may be better suited to identifying which specific design idea dominates the design process, Strand Maps support

analyses of how the design idea was transformed through a series of design representations, implemented in a diversity of design materials.

TCC was first mentioned in relation to the contest during the initial meeting with BIG, and at this early stage BIG showed an interest in the material, and the team agreed to use TCC, together with other sources of inspiration, in the collaborative process. Therefore, TCC was selected as one of a total of 15 technologies and materials that formed the basis for inspiration cards for the subsequent workshop (Figure 10, cluster 2). The TCC inspiration card had a short text (Figure 10, 2.1) and a picture of TCC in two different use-scenarios (Figure 10, 2.2). Furthermore, a video was used (Figure 10, 2.3) to illustrate the colour-changing properties of TCC.

In the subsequent inspiration card workshop (Figure 10, cluster 3), the TCC inspiration cards and the video in particular caught the team's attention, and dominated a significant part of the workshop as a recurring subject. BIG was especially fascinated by the possibility of literally integrating a slowly updating screen into the building's construction, which quickly led to sketches of principles for controlling TCC's temperature, and a discussion of the precision of this unique type of display. One of the ideas was to use the layout of water pipes in the walls as the basis for controlling the TCC (see Figure 10 3.2 and the sketch in Figure 11).

Despite the narrow focus on TCC after the workshop, the other undocumented ideas helped clarify the overall goal for the team members, who had diverse backgrounds and



Figure 11. Layout of water pipes in the wall.

interests. Despite, or perhaps because of, the narrow focus, we wished to explore potential uses of TCC, and a series of illustrations (Figure 10, 4.1) and animations (Figure 10, 4.2) was produced, in order to do so. The various visuals illustrated TCC in relation to the museum's façade, the building's entrances, and the lobby area.

During a subsequent meeting with a digital artist, focusing on ways of using TCC in the context of the museum, the complexity of TCC's possibilities led to an unmanageably wide design horizon for TCC, which was put into a systematic overview in terms of a matrix diagram (see Figure 12).

The visual material from cluster 4 and the systematic approach in cluster 5 were com-

bined during an alignment meeting with BIG (Figure 10, 6.1). From a design research perspective, we found that a combination of easily understandable visual scenarios (Figure 10, 4.1 and 4.2) and the more abstract but open-ended systematic representations provided a productive platform for the subsequent work with TCC, although for our partners at the architectural firm it was easiest to relate to the visual scenarios.

For a final time we broadened the TCC design horizon (Figure 10, cluster 7). The systematic approach (Figure 10, 5.1) generated quite a handful of ideas, which were subsequently evaluated with regard to a set of criteria we received from BIG, which had made the final decision concerning the overall concept for the building structure (Figure 10, cluster 8). This was the final alignment to be agreed upon, and made it possible for us to work in a focused manner on three different possibilities for TCC in the specific situation and museum setting (see the Focal Map in section 5 for further details).

#### Findings from using the Strand Map

Strand Maps capture and visualize the various articulations and materializations of specific design ideas that have emerged from sources of

inspiration. In our research, we have found Strand Maps especially useful in the following respects: (1) The very act of making the maps generates insight and establishes shared understandings among researchers, regarding how a design idea has evolved. There can be a tendency here to lose perspective and become absorbed in the immediate materialization of a design idea but Strand Maps may help overcome this tendency by making clear the evolution of the idea. (2) The Strand Maps highlight the multiplicity of digital and physical design materials being used, and how each of these addresses a specific aspect of the design idea. Some of the materializations address a specific aspect of the design idea, and others, like the matrix, provide insight into the complexity of the design space. (3) The Strand Maps point to specific transformations in the gaps between two or more identifiable materializations, and thus lead design researchers to make more detailed inquiries into the phenomena and events that may have brought about these changes – inquiries that may well be explored through the creation of Focal Maps.

#### Focal map: from experiments to ideas

Having analysed the design process using Overview and Strand Maps, we now present

LOCATION	SITUATION	INTERACTION SENSING	INTERACTION STYLE
Facade	Passing by	Autonomous	Movement
Plaza	Arrival	Passive	Gesture
Park	Transit	Active	Touch
Metro	Resting		

Figure 12. Excerpt from the matrix.

three Focal Maps employed to analyse a specific situation identified on the TCC strand, namely a series of interrelated experiments into the properties of TCC, which occurred in the latter part of the process (in the phase marked VIII in the Overview Map, Figure 7). Focal maps can be employed in a large number of situations, ranging in time and scope from specific, small-scale design experiments to longer stretches of design considerations and events. With regard to our overarching intention of examining the interrelations between sources of inspiration, design materials, and experiments and ideas, focal maps are specifically intended to support documentation and reflection on experiments and their role in shaping design ideas. The rationale for presenting the three selected Focal Maps in this section in detail, is, in part, to illustrate the level of detail of the maps, and in part to offer insights into how these specific experiments transformed our understandings of the uses of TCC.

#### Experiments into the expression and perception of TCC

The series of experiments described here occur at a point in time at which CAVI and BIG had agreed to work on three ideas for the integration of TCC in the museum proposal. TCC being a new and unknown technology, CAVI conducted a number of experiments to further explore the potential of this material. These

explorations included a number of experiments into the expression and perception of the TCC.

We will focus here on a triad of experiments, which followed one another in rapid succession. The specific object of the experiments was to explore the appearance and perception of images as they could be expressed using TCC. This was a highly relevant experiment, since the material had not previously been used in the way proposed by CAVI. This phase of experimentation was initiated by a series of rapid-fire experiments (see Figure 13), in which we tried out a number of filters, a photo manipulation application to test potential visual expressions of TCC; applying and evaluating each filter took less than a minute. This type of experiment may, in Schön's (1983, pp. 145–146) terminology, be conceived of as *an explorative experiment* in which the designer acts not with a specific end in mind, but rather to explore the potential of the situation. Having carried out these rapid-fire experiments, we moved on to three more detailed experiments into the potential appearance of TCC. These experiments may be conceived of as *hypothesis testing experiments*, in that we had now formed conceptualizations and hypotheses of potential TCC expressions, and needed to then test them.

These experiments began with the composition of a series of collages combining concrete imagery and a Van Gogh self-portrait (deemed relevant to a museum setting), using computer

graphics software (summarized in the first Focal Map in Figure 14).

This resulted in a Van Gogh portrait of various degrees of opacity, illustrating the transition from low heat intensity (=completely transparent image/plain concrete) to high intensity (=clear image of Van Gogh) (see the first part of Figure 15).

This approach was chosen since we were familiar with the computer graphics software, and expected it to yield results. The insights from the first experiment indicated that the TCC visual effect was successful; however, the Van Gogh portrait bore an uncanny resemblance to Lenin, which we deemed unsuitable for a Polish museum competition, due to historical considerations. Thus, a second, very similar experiment was carried out, using the image of Leonardo da Vinci's Mona Lisa portrait, summarized in the second Focal Map in Figure 14.

The procedure and rationale behind this experiment were the same as in the first experiment, resulting in an effect and imagery (see the second part of Figure 15) that we chose to further explore in the design process. This prompted the third experiment, in which the imagery was rendered in an approximated 3D model of the museum surface (summarized in the third Focal Map in Figure 14). A human model was placed into this, and a series of 3D images, ranging from a close-up to a more distant view, was rendered (see the third part

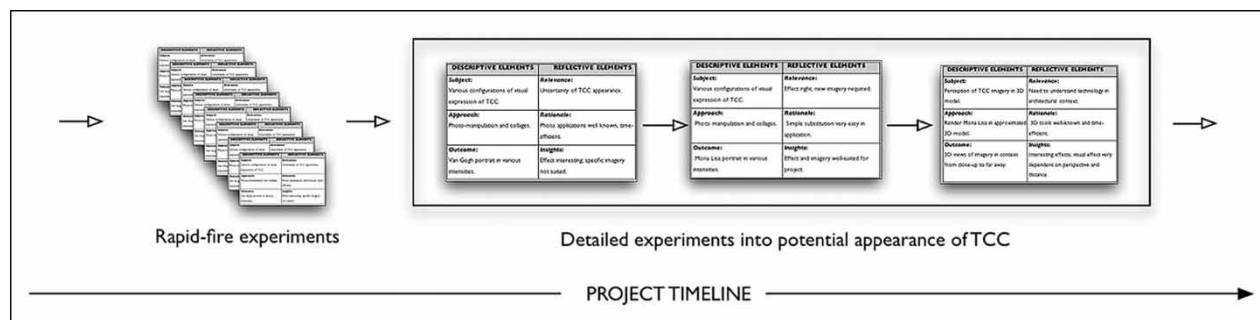


Figure 13. Strings of experiments into the expression and perception of TCC.

DESCRIPTIVE ELEMENTS	REFLECTIVE ELEMENTS	DESCRIPTIVE ELEMENTS	REFLECTIVE ELEMENTS	DESCRIPTIVE ELEMENTS	REFLECTIVE ELEMENTS
<b>Subject:</b> Various configurations of visual expression of TCC.	<b>Relevance:</b> Uncertainty of TCC appearance.	<b>Subject:</b> Various configurations of visual expression of TCC.	<b>Relevance:</b> Effect right, new imagery required.	<b>Subject:</b> Perception of TCC imagery in 3D model.	<b>Relevance:</b> Need to understand technology in architectural context.
<b>Approach:</b> Photo-manipulation and collages.	<b>Rationale:</b> Photo applications well known, time-efficient.	<b>Approach:</b> Photo manipulation and collages.	<b>Rationale:</b> Simple substitution very easy in application.	<b>Approach:</b> Render Mona Lisa in approximated 3D model.	<b>Rationale:</b> 3D tools well-known and time-efficient.
<b>Outcome:</b> Van Gogh portrait in various intensities.	<b>Insights:</b> Effect interesting; specific imagery not suited.	<b>Outcome:</b> Mona Lisa portrait in various intensities.	<b>Insights:</b> Effect and imagery well-suited for project.	<b>Outcome:</b> 3D views of imagery in context from close-up to far away.	<b>Insights:</b> Interesting effects; visual effect very dependent on perspective and distance.

Figure 14. The three Focal Maps describing the visual experiments into TCC.

of Figure 15). Again, part of the rationale behind the chosen method was based on our familiarity with the required software. The insights gained were that, from a distance, TCC imagery is clear and recognizable but, as observers move closer, the pixelation makes it harder to recognize. The combined experiments yielded an understanding of imagery using TCC, when perceived from various distances and angles, and the results were convincing enough for this idea to be incorporated into CAVI's final contribution to the museum proposal.

#### Findings from using Focal Maps

Focal Maps prompt reflection on the experiments that are at the core of moving from initial sources of inspiration towards fully formed design concepts. Our use of the maps

reiterates the notion that many design experiments serve to understand, explain, and frame challenges, rather than to solve them. This is a key characteristic of executing design in practice, which is by nature an undertaking influenced by multivariate factors; i.e. even if we try to bracket our design experiments to focus on specific aspects, we are often presented with results that go beyond what we set out to explore. For this reason, the transformation of design ideas through materializations often has the character of strings of experiments, as outlined in this section. We have shown how the maps may be used in a micro-analytical fashion, to point out specific iterations of experiments into the various expressions of TCC; however, we speculate that Focal Maps may also be employed to analyse experiments at a higher level of abstraction.

Of practical relevance to design researchers wishing to use the maps, our use of the maps has led us to appreciate a number of benefits, primarily that (1) the reflections they prompt are natural extensions of the reflections that emerge from using Overview and Strand Maps, (2) the format of Focal Maps is very easy to respond to, in that they lay out the reflection process in a straightforward manner, by coupling descriptive and reflective elements in a clear-cut line of inquiry and argument, and (3) a Focal Map, if it is completed immediately after the event it maps, captures insights into events that may be skewed or distorted in later, retrospective analysis.

#### Conclusion

Having explored the specific use of the maps for design reflection in the Warsaw MoMA



Figure 15. Illustrations from the three visual experiments into TCC.

case, we sum up the findings from using each type of map. We then broaden the scope and discuss the use of the maps in combination, suggest ways in which design researchers might use the maps, and discuss the advantages and drawbacks of doing so.

The Warsaw MoMA Overview Map presents a thorough, albeit abstract, account of main events in the project, with a particular focus on sources of inspiration and the emergence of ideas. In spite of the high level of abstraction, it is hard for observers outside the project to get an overview understanding of the project by means of the maps. They are primarily intended for use among design researchers; for the purpose of conveying a design process to outsiders, they must be supplemented with other accounts of the process. The complexity of the design process is such that the collection of maps presented in this paper by no means represents all aspects. Although CAVI contributed only to the interactive elements of the final proposal for the museum, the design process proved too complex to represent exhaustively, and even seemingly simple design moves in projects can contain interesting elements of insight, depending on the interests of those employing the maps. At a practical level, a software application for creating and updating Overview Maps would be helpful, because of their complexity. To this day, we use standard illustration and image editing software; however, a more dedicated solution would be preferable, especially if maps are to be created and updated by several researchers. At an analytical level, although the map can stand alone as a tool for reflection on general trends and design horizons, we find that it functions more effectively when used in conjunction with Strand and Focal Maps.

Although we have developed the maps in a design case in which we ourselves were design participants as well as researchers, our subsequent work with these types of maps indicates that it is also possible to use the method to

capture processes in which the researchers are not directly involved; that is, the maps may be constructed from the outside as well as from the inside. However, direct engagement in design processes offers access to a number of aspects which may be difficult or downright impossible for outside observers to study. On the other hand, an engaged inside perspective invariably implies affinities and blind spots, which are not present from an external perspective. In our use of the maps so far, we have focused on presenting and analysing a multifaceted case study. Thus, we have used the maps to present knowledge that unfold the details of rich design situations. Whether or not use of the maps can lead to more generalizable knowledge about design processes will depend on focused future uses of the method.

Due to the general complexity of design processes, employment of design reflection maps consequently relies on the design researchers considering the relevance criteria for their use. Since the maps are primarily intended as tools for reflection and analysis, they are intentionally flexible and negotiable, e.g. an Overview Map may guide the attention towards key points in the overall process, but establishing what constitutes a noteworthy strand for analysis and reflection is ultimately up to the design researcher(s). The maps are intended to create awareness, and allow for explication of design moves that have influenced the process, rather than to suggest how these moves be interpreted.

Strand Maps capture and visualize the various articulations and materializations of specific design ideas that have emerged from sources of inspiration. The Strand Maps have been especially useful with regard to the way in which various aspects of the main design idea have been explored in a multiplicity of digital and physical design materials, each addressing a specific aspect of the design idea.

Focal Maps prompt reflection on the experiments from initial sources of inspiration through 'a web of moves, discovered conse-

quences, implications, appreciations, and further moves' (Schön, 1983, p.129), towards fully formed design concepts. Given the complexity of design processes Focal Maps aim to pinpoint and capture specific incidents, which might otherwise be obscured by complexity. Different types of experiments contribute to the design process in different ways. With the scope of the paper in mind, we have focused on exploration and hypothesis testing experiments in order to illustrate the combination of descriptive and reflective properties of Focal Maps; we speculate that further systematic use of the maps by design researchers may support comparison and expansion of the notion of design experiments.

Each type of map has specific uses and limitations, and an understanding of these is crucial for the rewarding use of the maps. For example, Overview Maps highlight main trends and shifts in the design process, but do not facilitate detailed understanding of specific design moves; Strand Maps support comprehensive reflection on specific design ideas over stretches of time, but do so at the cost of other potentially influential elements in the design process; Focal Maps allow for in-depth analysis of specific design moves, but do not facilitate conceptions of how these moves affect the overall process. The three types of maps are therefore well suited to development and use in combination – i.e. an Overview Map may indicate that something important happened at a certain point in time, which prompts the use of Strand or Focal Maps to explicate detailed connections and moves, and the use of a Strand Map may highlight a certain pattern whose importance can be clarified using an Overview Map, or further analysed using Focal Maps. Thus, when using the maps, we recommend a tactic of 'zooming' in and out between levels of abstraction, based on the predetermined relevance criteria for the research process.

While this has concrete advantages in the design research process, as outlined through-

out this paper, we must stress that there are elements of the design process that are obscured or possibly ignored in this perspective. For instance, by placing the main emphasis on sources of inspiration, design materials, and experiments, the importance of dynamics and relations between different actors and stakeholders in the design process is momentarily downplayed. The insights of the maps may, however, help identify such relations, through the changes in design ideas. For instance, in the Warsaw MoMA case we can identify a radical convergence of effort in one specific event, the workshop presented in section 3.3. This major shift is the outcome of negotiations, relations, and decisions amongst stakeholders in the project, aspects that are largely outside the scope of this paper. Thus, we do not propose that the maps for design reflection should be the sole design artefact for researchers, but rather that they provide insights into specific aspects of design processes and, to reiterate the point, that design researchers apply them in light of the relevance criteria set up for their research inquiries. We have found that the maps offer a structured approach to capturing and understanding interrelations between sources of inspiration, design materials, and experiments in ways not supported by other methods. Although we have not worked actively to develop alternative maps, it will very likely be of interest to other design researchers to create maps that highlight other aspects of the design process, such as mapping stakeholder relations and contributions, end-user involvement, or other aspects entirely.

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### References

- ag4 (2006). Media Facades. Cologne: daab.
- Andersen, N. E., Kensing, F., Lassen, M., Lundin, J., Mathiassen, L., Munk-Madsen, A., & Sørgaard, P. (1990). *Professional systems development: Experiences, ideas, and action*. Englewood Cliffs, NJ: Prentice-Hall.
- Atwood, M. E., McCain, K. W., & Williams, J.C. (2002). How does the design community think about design? In *Proceedings of the Conference on Designing Interactive Systems* (pp. 125–132). New York: ACM Press.
- Foster, J. (1996). *How to get ideas*. San Francisco: Berrett-Koehler.
- Gedenryd, H. (1998). *How designers work*. Doctoral dissertation, Lund University Cognitive Studies, Lund, Sweden.
- Halskov, K., & Dalsgård, P. (2006). Inspiration Card Workshops. In *Proceedings of DIS 2006* (pp. 2–11). New York: ACM Press.
- Halskov, K., & Nielsen, R. (2006). Virtual video prototyping. *Human-Computer Interaction Journal*, 21, 199–233.
- Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.
- Jepsen, L. O., Mathiassen, I. & Nielsen, P. A. (1989). Back to thinking mode: Diaries for management of information systems development projects. *Behaviour and Information Technology*, 8(3), 207–217.
- Kelly, T. (2001). *The art of innovation*. New York: Random House Inc.
- Klemmer, S. R., Hartmann, B., & Takayama, L. (2006). How bodies matter: Five themes for interaction design. In *Proceedings of DIS 2006: ACM Conference on the Design of Interactive Systems*. State College, PA. New York: ACM Press.
- Lanzara, G.F. (1983). The design process: Frames, metaphors and games. In U. Briefs, C. Ciborra, & L. Schneider (Eds.), *Systems design for, with and by the user* (pp. 29–40). Amsterdam: North-Holland.
- Lanzara, G. F., & Mathiassen, L. (1984). Mapping situations within a system development project. *DAIMI PB-179, MARS report no 6*. Århus, Denmark: Department of Computer Science, Aarhus University.
- Lervig, M., & Madsen, K.H. (2003). Artists in the virtual studio. In K.H. Madsen (Ed.), *Production methods: Behind the scenes of virtual inhabited 3D worlds*. London: Springer-Verlag.
- Löwgren, J., & Stolterman, E. (2004). *Thoughtful interaction design: A design perspective on information technology*. Cambridge, MA: MIT Press.
- Madsen, K.H. (1994). A guide to metaphorical design. *The Communications of the ACM*, 37(12), 57–62.
- Materio (2005). *Material World 2: Innovative materials for architecture and design*. Basel: Birkhäuser Basel Publishers.
- McDonnell, J., Lloyd, P., & Valkenburg, R.C. (2004). Developing design expertise through the construction of video stories. *Design Studies*, 25(5), 509–525.
- Pedgley, O. (2007). Capturing and analysing own design activity. *Design Studies*, 28(5), 463–483.
- Sanders, E. (2005, March). Information, inspiration and co-creation. *The 6th International Conference of the European Academy of Design*, University of the Arts, Bremen, Germany.
- Schmidt, K. (1997). Of maps and scripts: The status of formal constructs in cooperative work. In *Group'97: the Integration Challenge* (pp. 138–147). Phoenix, AZ: ACM.
- Schön, D. (1983). *The reflective practitioner*. New York: Basic Books.
- Schön, D. (1988, July). Designing: Rules, types and worlds. *Design studies*, 9(3), 181–190.
- Schön, D. (1991). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.
- Schön, D. (1992, April). Kinds of seeing and their role in design. *Design studies*, 13(2), 135–156.
- Schön, D., & Bennett, J. (1996). Reflective conversation with materials, in bringing design to software. In T. Winograd (Ed.), *Bringing design to software*. New York: ACM.
- Smith, O. F. (2006). Object artifacts, image artifacts and conceptual artifacts: Beyond the object into the event. *Artifact*, 1(1), 4–6.
- Suchman, L. (1987). *Plans and situated actions*. New York: Cambridge University Press.
- Wakkary, R. (2004). Design and complexity: Research into practice. In *Proceedings of the Sixth International Consciousness Reframed* (pp. 440–448). Beijing, China.
- Wanie, C., Atwood, M., & McCain, K. (2006). How do design and evaluation interrelate in HCI research? In *Proceedings of the 6th ACM Conference on Designing Interactive Systems* (pp. 90–98). New York: ACM Press.
- Zimmerman, J., Forlizzi, J., & Evenson, S. (2007). Research through design as a method for interaction design research in HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 493–502). CHI '07. New York: ACM.