Digital Tools for Supporting Collaborative Activities in Design Processes

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MOTIVATION

Design methodology is increasingly influencing Human-Computer Interaction (HCI) as well as other traditionally engineering-oriented disciplines. Unlike analytical thinking in classical engineering design processes, "design thinking" is an opportunistic, yet structured activity based on building up and combining ideas. It encourages maximum input and participation without early judgments that might lead to a fear of failure during ideation and prototyping phases. Due to an increasing need for creativity and innovation in HCI, new design methods and techniques were introduced in early process phases, which also led to a novel perspective called "Interaction Design". One key characteristic of these methods is collaboration and embodied practice [1].

When designers are creating and revising ideas during early interaction design stages, they often harness the spatial properties of the environment. Paper sketches, post-its or other physical artifacts are shared on large whiteboards or spread out on tables and walls for comparison and discussion with other designers. In design studio environments, the room itself is an important tool that allows organizing information in an informal and spatial way. Especially during group activities, physical accessibility and visibility of artifacts is crucial for efficient communication. This is one of the reasons why interaction designers often prefer to work with pen and paper during creative group activities. Paper provides a flexible semi-private workspace while sharing is as simple as pinning the paper on the wall or spreading it out on the table.

However, when using desktop-based electronic tools, the artifacts that are created are often hidden in file systems and are hardly accessible during group activities. Nevertheless, digital artifacts are frequently needed for documenting ideas and progress, for sharing across digital networks and for keeping archives in digital repositories over the course of a design process. Especially in interaction design, artifacts are eventually needed as digital representations.

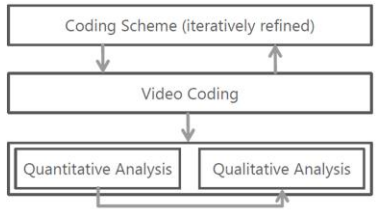
RELATED WORK & RESEARCH OBJECTIVES

Our research community is well aware of these issues and has developed a range of tools and guidelines that aim on supporting general design practice with interactive technology. However, a lot of these efforts focus on high-level activities like "creative group work" or "designing". Therefore it is necessary to investigate application of interaction concepts on specific techniques that are actually used in interaction design practice. A detailed analysis of the embodied practice of these techniques is required to examine which tasks can actually be supported by digital tools and which tasks we should leave to human skill and experience (first research objective). Recently, novel developments in the area of natural user interfaces – like multi-touch tabletops and digital pen & paper – but also increasing availability of interactive display space have revealed a great potential for supporting creative tasks. However, it is yet to examine if these technologies can be applied to augment practice (second research objective) [2,3].

REQUIREMENTS ANALYSIS

In order to inform our research, we conducted an extensive observational study during a three-month design project [4]. The goal this study was to identify the problems that are faced in embodied practice regarding specific design techniques (first research objective). This detailed investigation is necessary because it is not possible to derive this specific knowledge from literature only. Yet, only a detailed analysis gives adequate data that will allow measuring the effects of specific interaction techniques. For that purpose, we designed a custom design process that was based on a composition of selected design techniques. As we were not able to observe real designers over such a long period of time, we integrated the study into an interaction design course. Participants were 20 students that were divided into four groups. During our observation we acquired data in the form of video recordings, photos, interview notes and structured observation notes. Overall we collected over 43 hours of video footage.

Due to our findings while observing the design sessions and after reviewing the video material, we focused on one design technique for a detailed analysis as it was exemplary for the basic phases "ideation", "presentation" and "discussion" that we could identify across all design techniques. The "Affinity Diagramming" technique (see Figure 1, a) is based on post-it notes that are collaboratively created and then restructured to build a common representation for sense-making in the group. Due to the limitation to small post-it notes and short sentences, the frequency and number of individual interactions (writing, sharing and evaluating) is higher than in most other design techniques. Therefore, it is especially suited for quantitative analysis since it involves a high frequency of events. We analyzed four design sessions (about 7h of video) on four levels: (1) interaction



Attention	Personal Workspace	Team Members	Whiteboard
Ideation	77.07%	5.8%	0.01%
Presentation	11.15%	57.2%	9%
Discussion	3.49%	20.06%	68.55%

Figure 1: Research methodology: Observational Study (a), Data Analysis (b), Prototype Implementation (c)

with physical artifacts; (2) social interactions between team members; (3) workflow of actions; and (4) attention in the physical environment. The video was coded using an iterative process, which means that the coding scheme was refined while analyzing the videos (see Figure 1, b). The quantitative analysis was based on the frequency of coded events. This data was then used for qualitative analysis which was applied to interpret the data distribution.

As a result of the study, we identified specific issues and requirements that need to be addressed when designing digital design tools for collaboration. For example, we found that the physical properties of paper artifacts are crucial for ideation and sense-making tasks on the individual and collective level, as they efficiently support holding, sorting and browsing actions, which we interpret as a form of embodied thought. Looking for and explaining artifacts were the primary activities during discussion, which was also identified as the most complex task. Pointing gestures and spatial arrangements were identified as crucial properties of implicit communication in the groups. However, we found exactly these issues to be growing more complex when the amount of artifacts increased. Overall, we identified following themes that we seek to support when developing interaction techniques: (1) physical interactions with artifacts; (2) private and shared workspaces (3) spatial navigation; (4) support for group discussions; and (5) augmentation with digital information and tools.

WORKING HYPOTHESES

By considering the results of our study, established high-level guidelines and the limitations of related work, we developed own design concepts to address these issues with following working hypotheses: A shared, cross-display workspace can be used to support spatial navigation tasks (WH1); Detail and context techniques can be used to make discussion more efficient and to deal with a growing number of artifacts (WH2); Digital pen & paper and multi-touch technology is capable of maintaining the benefits of physical interactions and private/social workspaces (WH3), while at the same time enabling augmentation with digital tools to make tasks more efficient (WH4).

PROTOTYPE IMPLEMENTATIONS

In order to test our hypotheses (second research objective), we implemented three functional prototypes that we will evaluate with a series of case studies. Each prototype is designed for a specific design technique but employs similar interaction concepts that we derived from our working hypotheses. We currently have implemented digital tools for the design techniques “Affinity Diagramming” (see Figure 1, c), “Brainsketching” [5] and “Ideation Workshops based on Image Stimuli” [6]. The technical foundations of these tools are based on the ZOIL software framework, which is developed within our group [7]. A shared workspace across displays is realized by synchronizing interfaces over a central database. Focus and context navigation is supported with a zoomable user interface that can be navigated independently on different displays. We designed different mechanisms for focusing on specific artifacts during discussions and for getting overview on the overall activity. Lightweight search functions are integrated to facilitate search for artifacts created by different persons. Digital pen & paper [8] is primarily employed for content creation tasks within ideation phases and for supporting private workspaces. Transfer of information from physical artifacts to digital representations is realized by using optical marker recognition on interactive tabletops. Multi-touch interaction techniques are used for sorting and browsing tasks during collaborative sense-making. Digital highlighting of artifacts based on touch interaction is used for supporting pointing gestures across displays. We also integrate technique-specific functionality to improve the workflow of each design technique (e.g. retrieving images based on post-it contents).

CURRENT STATUS

The prototype implementations will be evaluated within case studies that we are currently planning. We will again use observational studies that will be integrated in an interaction design course. This will allow us to measure the effects of our novel approaches compared to traditional practice. However, in the future we will also be able to get feedback from design professionals.

REFERENCES

1. Geyer, Florian. *Blended Interaction Design: A Spatial Workspace Supporting HCI and Design Practice*. Interact 2009: Proceedings of the 12th IFIP Conference on Human-Computer Interaction, Springer, Uppsala, Sweden, p. 844-847, Aug 2009

2. Geyer, Florian; Reiterer, Harald. *A Cross-Device Spatial Workspace for Artifact-mediated Collaboration*. CHI 2010 Workshop - Artifacts in Design: Representation, Ideation, and Process, Atlanta, USA, Apr 2010

3. Geyer, Florian; Reiterer, Harald. *A Cross-Device Spatial Workspace Supporting Artifact-Mediated Collaboration in Interaction Design*. CHI 2010 Extended Abstracts on Human Factors in Computing Systems, ACM Press, Atlanta, USA, p. 3787-3792, Apr 2010

4. Pfeil Ulrike; Geyer, Florian; Reiterer, Harald. *The Role of Artifacts and the Physical Work Environment in Collaborative Design Activities and Implications for Digital Tools*. Full paper submitted to CHI 2011

5. Geyer, Florian; Jetter, Hans-Christian; Pfeil, Ulrike; Reiterer, Harald. *Collaborative Sketching with Distributed Displays and Multimodal Interfaces*. to appear in Proceedings of ITS 2010: The ACM International Conference on Interactive Tabletops and Surfaces 2010, ACM Press, Nov 2010

6. Geyer, Florian; Klinkhammer, Daniel; Reiterer, Harald. *Supporting Creativity Workshops with Interactive Tabletops and Digital Pen and Paper*. to appear in Proceedings of ITS 2010: The ACM International Conference on Interactive Tabletops and Surfaces 2010, ACM Press, Nov 2010

7. Jetter, Hans-Christian; Gerken, Jens; Zöllner, Michael; Reiterer, Harald. *Model-based Design and Prototyping of Interactive Spaces for Information Interaction*. In Proceedings of HCSE'10, the 3rd Conference on Human-Centered Software Engineering, Springer, Oct 2010

8. www.anoto.com