Digital War Room for Design

Requirements for Collocated Group Work Spaces

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Abstract. In this paper, we describe the requirements elicitation for a digital war room – a group work facility to support people interacting with digital (and analog) materials. The target user group is product design teams and construction engineers/architects. Main requirements for an interactive group work space include fluent sharing of documents within the facility and ability to comment on them, support for both analog and digital sketching and writing by hand, minimum of three displays allowing parallel tasks and comparison of different alternatives and the importance of the physical properties of the facility.

Keywords: Requirements elicitation, user-centred design, group work, design project room, working with digital materials, collaboration spaces.

1 Introduction

Product or service design leverages participants' skill set and past experiences with available information about the task at hand in order to create a new solution to a given problem. It is characterized by highly interactive processes among multidisciplinary project groups. As more and more design artifacts and documents are digital, the designers also want to use and share these digital documents among themselves in their collaboration situations. Making changes to the working habits and environments is hindered by traditional, yet outdated, work practices and tools. Earlier learned or used methods are often hard to change. Product design also requires working with very complicated stakeholder networks both within a company and across subcontractors and marketing channels. And above all, the employees' ability and willingness to cope with the fast changes in their working environment is limited.

Some of the often tried remedies to these ailments are to promote and adopt digital processes to accelerate work flow and introduce new information and communication technology (ICT) tools and systems to the workers. Some of the proposed solutions include dedicated ubiquitous group work facilities with large visual displays [1], combining digital and analog tools to support meetings [2] and use of large multi-display arrays [3]. Lately these kinds of solution have been referred to as blended spaces [4].

This paper describes the research conducted in the DiWa – Digital War room project aiming to develop an interactive digital collaboration space that enables fluent

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group interaction with digital, mainly visual, contents. It will act as an active tool for design, collaboration and assessment. Our primary design drivers are 1) a better inclusion of rich media about the actual end-users and their experiences [5] to user-centred design (UCD) process, 2) natural interaction with large visual displays and digital artifacts, 3) leverage the synergies between physical and digital design practices and 4) to finally update the omnipresent "one data projector and a flip chart" meeting room standard design to the 21st century.

This paper describes the first half of our project where our goal was to find out and understand our stakeholders' needs and expectations towards the use of interactive group work spaces. We will ground this knowledge with current state-of-the-art through a systematic literary review and validate the resulting solutions with our target users to receive directions for our next steps.

2 Literary Review

Group work and collaboration taking place in technologically enhanced spaces is a combination of multiple disciplines and almost unlimited topics. We did a systematic literature review to act both as a foundation for our project and as a source for validation and justification for our final requirements. With 49 search terms applied to five academic publication indexes (ABI/Inform, ScienceDirect, ACM Digital Library, IEEE and Google Scholar) we found total of 13,6 million hits, of which 907 most relevant where browsed through and for 168 of these written summaries were created. The written summaries were used to group the papers into eight categories with variable strength interconnections between them.

Group Work. Understanding group work or collaboration practices among designers is important in order to be able to design new technology to support them. Working in a group, in general, seems to be a messy event to understand. According to Cross and Clayburn [6] even if there is a plan for the design session, the designers tend to pursue unplanned activities also in collaboration. They also claim that the main challenge in such sessions is to reach a shared understanding about the problem; this is not what happens naturally, there can be misunderstandings even in the apparently shared concepts.

The basic activities designers do in a collaborative design meeting are sketching and talking e.g. telling design stories. Sketching, however, is not the most used tool. It seems that verbalizing (spoken and written) is more dominant. But it could be that the combination of sketches and speech is actually the most powerful way of communication. Linking these two design artifacts is generally done by gesturing. [7]

Work Practices. Poulsen & Thøgersen [8] conclude that the whole human body is engaged in the sense making process. They further argue that designers' communication and thinking cannot be understood with only words, and it cannot be reduced to gesturing. Also Tholander et al. [9] observed this in design activities where walking was used as a way to shift the focus in the design. Sketching and gesturing are done also for the sake of the person's own understanding rather than merely as tools for communication

[10]. According to Vyas et al. [11] also other material artifacts beside sketches are important in the communication of collaborative design. These artifacts mediate the experience of other designers in the group and are not just interaction aids.

Space Design. The design environment is an important part of the design process. By surrounding themselves with sketches, design models etc. designers get inspiration for new ideas and communicate existing ones. Especially important seems to be the ability to communicate multimodal information. [12]

Vyas et al. [13] also state that it is important to understand the physicality of design and its social aspects. Plaue et al. [14] observed real collaboration in companies and found that physical aspects of the spaces affect how people feel about the space. Their findings also indicate that technological changes were not required as often as environmental ones. Also Magadley and Birdi [15] have found that environment appears to be equally important as technology for the users.

System Design. Simultaneous actions in multi-surface, multi-user environments cause problems. Voice commands should be avoided [16] as well as individual mouse cursors as they cause confusion [17]. According to Tse et al. [16], small gestures help parallel individual work and large gestures increase collaboration, mode awareness is crucial if modes are used, container marking and location affect viewing them as group or personal territories and there are two types or joint multimodal commands. Jiang et al. [17] suggest that using a multi-touch screen promotes task awareness. Tse et al., Jacucci et al. [18] and Cesar et al. [19] agree that users should be presented with an option for transitioning between individual work and collaborative work. Tang et al. [20] promote the idea of using analogous technology to ease transitions. In their study a whiteboard was used to support users' existing work practices with new large display applications. Large collaborative displays however are often supplemental technologies as opposed to primary tools [21].

Interaction. In general, the bigger the display, the more physical its navigation is. Findings about physical navigation are however contradictory. According to Ball et al. [22] it increases the users' performance and is preferred by users compared to virtual navigation. When manipulating objects, planning time is shorter and users are able to perform more efficiently and are able to rotate objects around all axes [23]. However, according to Forlines et al. [24], users can perform better when using a mouse for one-handed input and fingers for two-handed input with large horizontal displays. Reilly [25] argues that immediate feedback is not necessarily needed when pointing at objects that are familiar and that users don't even need to look at them.

Requirements. It is paramount that the users of a multi-touch setup are aware of what is happening and what other users are doing. According to Carroll et al. [26], awareness is the key for mediated collaboration and tools. This can be translated to system requirements: fluid and fast interaction, users have to be aware which display is being controlled at all times, related objects are drawn together and users must be able to work on separate sub-tasks without interfering with others [27].

System Possibilities. Drag-and-drop has been advanced from mouse-only use to other environments. For large display tabletop interfaces users face a problem of reachability. A virtual grabber can be used to manipulate objects that are beyond user's immediate reach [28]. Authors argue that the virtual grabber could be used to interact with objects in wall screens from the tabletop in intelligent and responsive spaces. Hopmann et al. [29] have tried to bring tangibility back to drag-and-drop. In their study a remote control that detects gestures was used to transfer a picture from a TV to a digital photo frame. Their findings show that more feedback in the process is needed.

Video. Video indexing is the most popular subject for studies, since automated process for describing certain aspects of video would be preferable to laborious human annotation. Hu et al. [30] describe state-of-the-art of video indexing in their work covering topics such as shot boundary detection, key frame extraction, feature extraction from static key frames, objects and motions as well as video navigation.

Annotations are a good way to provide possibilities for navigation [31]. Also other strategies are reported in studies for navigating videos, from affective annotation timelines [32] to a more classic database solution where multiple ways of searching are supported [33].

Different approaches to help in searching video information have been suggested. Cordeiro and Ribeiro [34] have identified what they call low-level descriptors which can be analyzed for similarity and used for a retrieval system. Li and Wang [35] have created a method for searching videos based on faces, the information is automatically created combining visual and temporal video information to separate similar faces. By augmenting a video with other data (e.g. sensor data) and then providing search possibility for the combination of video and other data makes finding significant shots more easy [36]. Halvey et al. [37] on the other hand have created a collaborative tool that supports different search approaches.

3 Field Study

After the literature review, we performed a field study to gain a sufficient understanding of our stakeholders' operations and most importantly of their everyday collaboration situations and practices. The field study included observations (as a complete observer [38 pp. 228]) from 12 collaboration situations, five group interviews with total of 22 participants and six individual interviews. The analysis was based on Contextual Design [39] and it produced detailed descriptions and flow models for each stakeholder and a consolidated physical model of the shared aspects of the collaborative work environments.

Results. Our analysis indicated that all units had unique collaboration goals. On a detailed level there were only a few similarities in the everyday activities. However, on a higher abstraction level the collaborative work practices seem to coalesce and are elaborated on in the following sections.

From the field study it was clear that one of the key aspects in everyday collaboration was the versatility of situations ranging from working in pairs and tight collaboration in small teams to more formal meetings with agendas and schedules. In formal meetings making decisions was the main objective while the role of collaboration situations was mostly to share information, make decisions and distribute tasks. The amount of actual tasks done together in these situations differed in the studied units. Sketching and drawing were important co-creation activities. The role of external participants varied extensively from merely passing out information to creating new material together with the other participants.

The processed or viewed media in collaboration situations was mainly digital documents in several different formats, but also videos and digital photographs were used. Handled artifacts included drawings and sketches, very large plans and physical prototypes. The participants also more often than not had their own laptops as well as pen and paper for making notes in the collaboration situations. Documenting decisions and making notes of the work done were considered both difficult and cumbersome to do properly. It was also almost impossible to efficiently share these notes in real time to the collaborators.

The current facilities provided for collaboration were much alike for all studied units and thus it was possible to present them in one consolidated model. Several concerns were found with video conference systems; they require configuration before use and working software had to be installed on the computers. There are also severe incompatibility issues. Connectivity issues are also relevant for teleconference systems. With whiteboards and flip charts the most common problem was saving made notes. In the field study we found several strategies for saving the notes, for instance, photographing the flip charts or transcribing the notes by hand. In all meeting rooms there were only one projector or display, but in many cases participants would have needed to see several projections at the same time. Participants also had the need to point at things on the screen and in many cases a mouse pointer was used. The mouse pointer, however, was difficult to see by all participants.

4 Requirements for Collocated Group Work Spaces

After the field study, its results were integrated to the findings of the literary review in order to compile a list of 82 individual requirements for an interactive collocated group work space. These requirements were grouped into five common categories: space and layout, work practices, ICT and technology, remote collaboration, and interaction. The requirements were validated by presenting them to the stakeholders in a full-day workshop during which the participants rated the suggested features. At that time remote collaboration was considered out of scope for this project and it was not studied further.

The following paragraphs describe the interactive group work space based on the explicit requirements in the remaining four themes as well as summarize the stakeholder-specific requirements.

Space and Layout. The interactive group work space is intended for collaborative activities for three to six people, while the space still accommodates ten to twelve persons. The space is furnished to support the activities, but it also must be pleasant to be in. The importance of environmental aspects of the room was also found very significant for users in the literature [14-15].

Basic elements in the space are furniture, screens and equipment for controlling the system. The screens are placed so that all users are able to view them. According to one study users mostly prefer the screen which is in a 45 degree angle straight in front of them [27]. The table size and placement of all furniture can be modified depending on activity and needs. Conventional pen and paper collaboration tools are available.

Work Practices. The interactive group space supports all customary existing work practices [20], but also offers the possibility for multiple users to interact with digital and physical materials at the same time. The collaboration situations to be supported include formal meetings as well as real collaborative work. The space enables comparing several alternatives effectively which is essential in most team work (e.g. software development [40]). Other normal collaboration activities include sketching, commenting and comparing alternatives. The need to support sketching, both as individual and group activity, was also evident from literature [16, 41-42].

ICT and Technology. The interactive group work space and its equipment are operated as an independent system. This system provides versatile connectivity for personal devices as well as access into corporate data systems. Personal devices can be used to share documents and specific applications with the system. Biehl et al. [43] describe a framework for sharing applications and input in a multiple display environment.

The screens connected to the system are large and have adequate resolution. The placement and type of screens in the room can affect group interaction [44] and should thus be considered carefully. The system enables viewing and modifying several documents or materials by multiple users at the same time. The system also saves all activity and produced documents for later reference, and the system can digitalize physical documents and objects (e.g. [45]). The system manages different groups' and stakeholders' data separately from each other.

Interaction. The system supports several different ways for interaction to meet different needs arising from the activities and users' preferences. These different input methods include touch, mouse and keyboard. Multiple ways for interaction are encouraged by literature [46-47]. The interaction with the system can be done locally from the screens or remotely through the system with a separate device. Controlling the displays while seated is important [14]. Providing multiple sets of input devices and tablets also supports switching between different working styles [45].

Interacting with the system and different materials can be done by several users at the same time. When multiple users work simultaneously they have to be able to work

without interfering with each other and at the same time be aware of what they are controlling [27]. The system also has efficient tools for handling visual material, such as zooming and panning, as well as pointing at the materials.

Stakeholder-Specific Requirements. All activity within the space, especially decision making and the reasoning behind them, is saved for future reference. The system enables presenting and sharing documents to other users in the interactive space. Also viewing, sharing and editing multimodal materials, especially user research findings, is possible within the space. Vyas et al. [12] point out the importance of designers surrounding themselves with multimodal materials. Commenting and drawing on presented materials is possible.

The interactive space supports innovation by supporting specific ideation methods if needed, as well as enabling more free-form activities. Regarding design and other creative endeavors, researchers have recognized the need to support a wide range of methods so that users can choose the one that fits them and the task at hand [14].

5 Conclusions

After a field study on collaborative work with four stakeholders in addition to an extensive literature review covering both design and interaction with digital artifacts, we were able to define generic requirements for an interactive collocated group work space. With the aid of an abstract requirements specification [48] our technology and implementation independent description of the system's features and functionalities were understood and committed to by our various stakeholders.

The highest rated requirements fall into four distinct groups of: 1) collaboration: fluent sharing of documents within the facility and ability to comment on them, 2) supporting conventional work practices: support for both analog and digital sketching and writing by hand, 3) parallel and uninterrupted use: minimum of three screens allowing parallel tasks and comparison of different alternatives, and 4) physical properties of the facility: flexible and adaptive furniture and lighting, fast Internet connection and above all well-functioning ventilation and lighting.

Our design principles share the requirements for robustness and extendibility with other similar facilities referred in literature (e.g. [15, 27]). Our goal of defining a general purpose interactive space equally useful for all of our stakeholders may prove challenging during the implementation phases. But still due to the wide scope of interests within our stakeholders, the relatively high abstraction level of our requirements and the strong supporting evidence from literature, we argue that most of the described requirements are generalizable to most instances of collocated group activity in relation to digitally supported design activities and large displays.

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