

The interactive design collaboratorium

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Abstract This paper reports on an experimental process in which a prototype was developed of an interactive design collaboratorium, in cooperation with a group of usability designers. In a longterm research cooperation, this usability group has changed its work practice in order to work in the design collaboratorium. The design collaboratorium was developed to move usability design away from a lab towards an open physical and organizational space where designers, users and engineers meet and collaborate, or work alongside each other. The cooperation between researchers and the usability group has resulted in practical experimentation in projects and in design of an experimental design collaboratorium employing electronic whiteboards, 3D design documentation, etc. This experimental prototype has been evaluated in cooperative workshops. We report on the results of this evaluation.

Keywords: Interactive design rooms, usability design practices, cooperative design

1. Background

The design collaboratorium is an approach to usability design where the focus is on involvement of usability concerns early in design, concern for actual use rather than what is re-produceable in a lab, and for collaboration between the competencies of design and usability. The design collaboratorium has been developed (Buur & Bødker, 2000, Madsen & Borgholm, 1999) through practical experimentation in projects in three companies. One of these companies was Bang & Olufsen whose usability design work we focus on in the following. In cooperation with researchers, this usability design group has implemented aspects of the design collaboratorium. Studies of this implementation have been the basis for informing an experimental design of an interactive design collaboratorium prototype, employing electronic whiteboards, 3D design documentation, etc. This experimental prototype has been evaluated in cooperative workshops. We report on the results of this evaluation, and discuss requirements for the further design of interactive design room technology.

The vision of the design collaboratorium covers the following themes (Buur & Bødker, 2000):

It accumulates design knowledge. To serve as a reminder of important aspects of the design complex, the design collaboratorium contains places for summing up the various phases of design. It reflects the history of the project, the history of use, the history of the product line, etc.

It reflects the use context, both to constantly remind the design team of the people and the environment for which they design, and to make it easier for users, when invited to participate, to engage their tacit knowledge.

It inspires innovation by being equipped with artifacts and illustrations pointing out new directions either related to the work domain in question or unrelated to provoke contrast.

It supports open and closed cooperation between changing constellations of participants. People can enter and exit at will or in coordinated manners. A place where things may be left behind is a place to come back to. Doors can be closed when the participants decide so, and open to new participants when that is the choice.

1.1 Research approach and related work

The work on the interactive design collaboratorium draws upon experience and techniques from a number of different fields: Collaborative Virtual Environments (Churchill & Snowdon, 1998), Human-Computer Interaction and usability practice (Madsen & Borgholm 1999), and Computer Supported Cooperative Work.

Specifically, this work draws upon and expands on a number of studies of design rooms (Karat & Bennet, 1991, Madsen & Petersen, 1999) and design spaces (e.g. Büscher et al., 2000), by focusing on the development of a particular design practice, supported by interactive technologies.

Technologically, we have been inspired by interactive room technologies (e.g. Streitz et al., 1999), electronic meeting environments, (e.g. Pedersen et al., 1993), and whiteboard-based interaction, (e.g. Rekimoto, 1998). In contrast to many of these designs, our interactive design room draws from a longterm empirical study (Buur & Bødker, 2000, Madsen & Petersen, 1999) as well as from the particular problems of the current ways of working in the specific case. We explore the usefulness of recent technological gadgets, and this paper shows how questions arising out of the particular empirical case can inform general problems of interactive design rooms.

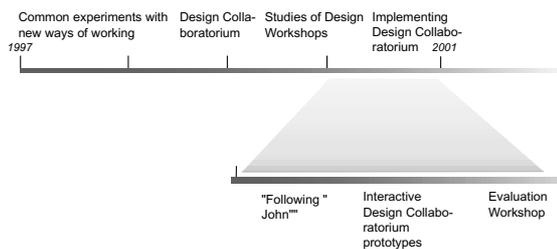


Figure 1. Timeline of the project

1.2 Structure of paper

The paper tells the story of a development involving empirical studies of a particular usability design practice (selected from a large body of work conducted over the last 4 years, supplemented with specific studies, see Figure 1), theoretical elaboration of findings, design proposals utilizing recent wall, portable and interaction technology, and design workshops in which the design prototypes were evaluated together with users see also (e.g. Buur & Bødker, 2000, Madsen & Petersen, 1999, Büscher et al., 2000). We have chosen to structure the paper so as to reflect the steps in the development process and conclude with a set of requirements for the interactive design collaboratorium.

2 Bang & Olufsen

Bang & Olufsen is a manufacturer of integrated video and audio products linked in a small network allowing the products to share services. The products are primarily installed in private homes. The usability work is linked to the design concept phase and the group is responsible for the interaction design quality of all Bang & Olufsen products. The work has been characterized by a high degree of division of work and qualifications: industrial designers design, engineers build prototypes, and the psychologist does the testing (Bærentsen & Slavensky, 1999). The main point of coordination between these groups was meetings where all groups would contribute to the discussion of prototypes. Users have primarily been brought into the evaluation process in tests, and the results of these tests have been fed back to designers and engineers in meetings.

3 A prototype design collaboratorium

The usability design group at Bang & Olufsen has chosen to implement the design collaboratorium by rearranging their use of space. In the following, we discuss the problems and potentials of the present work practice of the group, as it unfolds in and around the central meeting room, with respect to the visions of the design collaboratorium.

The group has basically created a workshop in the classical sense: a joint room where people can cooperate or work alongside each other. The room is the physical framing of workshops with users, usability evaluation sessions, meetings, and work activities of smaller groups of usability professionals, designers, and engineers; in parallel or interleaved with each other. Thus the room is used extensively by all group members, and serves a series of purposes. The room is equipped with a number of whiteboards of varying sizes. Further, it holds prototypes of earlier and present projects. The layout of the room has a traditional meeting table with whiteboards on the surrounding walls and prototypes positioned on shelves on the walls (see Figure 2).

We have followed one person—John—on his job for 3 days. John is project coordinator at the usability design group. As a project coordinator his job is to monitor and supervise the various design projects initiated by the group. On his job, John is in continuous personal contact with many people, both at Bang & Olufsen and from other companies i.e. subcontractors and external designers.

During the days when John was observed, we saw how he worked both in and outside the common room. The following characteristic work situations suggest the spectrum of different settings.

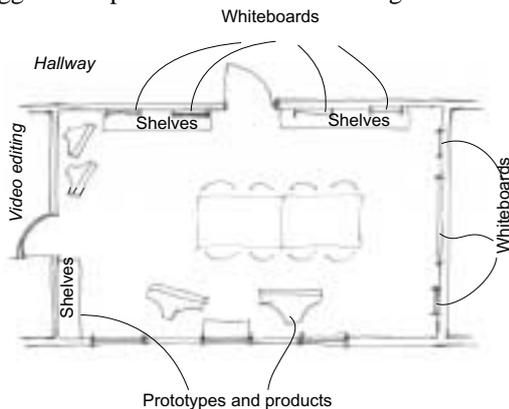


Figure 2. The design collaboratorium room

Situation 1 - the common meeting

Common meetings are formal meetings with very different and varying agendas ranging from deciding on holiday plans through status reports of design projects to intense brainstorming sessions. These sessions involve the entire usability design group, and they typically take place in the design collaboratorium. Decisions are partly materialized in the participants' personal notebooks and partly written down on the whiteboards in the room.

Situation 2 - the design meeting

Design activities takes place in offices or production areas with the purpose of furthering the design process. John and collaborators make joint sketches and develop prototypes based on ideas developed in earlier brainstorm meetings, or they discuss problems with the implementation of design decisions. This type of work relies heavily on knowledge of the intentions and design decisions made in earlier meetings, e.g. after a brainstorm session. John and other participants of these design meetings carry this information around as personal notes if materialized at all, and the information is passed on verbally to the implementors.

Situation 3 - spontaneous encounters

Spontaneous encounters with colleagues in hallways or in offices. These typically involve two to three persons discussing implementation problems and design issues. Such discussions are rarely captured in any formal way.

These work situations are characterized by a high degree of verbal interaction. Little is done to capture design decisions made in any shared form (pictures or notes) except for on whiteboards when available.

When discussions or decisions are captured, they are typically recorded in personal notebooks.

4 Key findings from current practice

The findings from following John and from other studies of the design collaboratorium at Bang & Olufsen are summarized through the headings of the four initial requirements of the design collaboratorium idea.

4.1 Accumulation of design knowledge

The present implementation of the design collaboratorium at Bang & Olufsen accumulates design knowledge in different forms:

In the design collaboratorium the presence of prototypes from present and previous projects serves to support an awareness in the group of ongoing projects. Exemplar previous products provide a sense of history of the company line. The design knowledge in the group is summarized in a set of principles for good interface design, which are kept as an A3 sheet of paper, pinned on one of the boards in the room, annotated with notes on a small whiteboard.

After a common meeting in the design collaboratorium all the whiteboards were covered with notes from a brainstorm. Minutes were produced from the meeting. Due to the quality of the brainstorm, however, it was decided that the whiteboards were to be left untouched for a week to inspire the people working on the project in their further work and to serve as a reference for an external designer, who was due to arrive later. Accordingly none of the whiteboards could be used for a week. While the whiteboards worked well during the brainstorm, i.e. they were used as point of reference and annotated during the discussions, the choice of leaving them untouched for a week severely limited the usefulness of the design collaboratorium for the purpose of other projects during that period.

Secondly, the usefulness of the notes was limited because they were only available in this specific room. Thus spontaneous encounters in hallways and design activities in other locations, discussing the same project, could not benefit from this resource.

Thirdly, the extent of the use of whiteboards and other means of shared sketching and note-taking both in and outside of the present design collaboratorium room varied. During some events nothing was noted down, whereas during others, all the boards were covered with notes and drawings capturing ideas, thoughts and proposals.

Hence, the present setting does not have the flexibility for supporting shifts between events on different projects during the day, while preserving continuity on the individual design projects. The lack of materialization in the design process constitutes an additional obstacle for the accumulation of design knowledge within and across projects.

In the various design situations we have observed, most often very few personal notes are taken. In some cases it is only when the process reaches the state where prototypes are produced that the design decisions made during the design process get materialized (see also Madsen & Petersen, 1999).

4.2 Inspiring innovation

In our previous work on the design collaboratorium, we have outlined essential elements in supporting creativity in cooperative design work (Bødker et al., 2000). We point out how past and present products and stylistic trends can serve to inspire innovation in future products. In the present implementation of the design collaboratorium, the presence of present and past Bang & Olufsen prototypes as well as competitors' products are brought into the discussions and thus inform the design of the future. Further, a team member is working to develop a set of principles for interaction design based on psychological theories, in this way making theory a possible source of inspiration in design work.

(Madsen & Petersen, 1999) pointed out how the flexibility of the design materials, and the physical organization of the room are important elements in supporting cooperation in design. Although the design collaboratorium holds prototypes of various forms, there are most often very few flexible, low tech materials like screendumps, pictures, post-it notes, posters etc. available. The prototypes cannot be modified on the spot and the lack of flexible materials makes it hard for the participants to materialize the discussions in a common form and to create a common ground for a continued discussion.

4.3 Reflecting use context

The context of use of Bang & Olufsen products is represented by a full scale living room which acts as test facility. Although this living room is located near the design collaboratorium, it is not a part of it at present. This separation continues because the tests are carried out by one member of the group and the experiences are brought into the group mainly by this person. The long-term vision is that the test room should be connected to the design collaboratorium through a video-connection so that the group can share experiences from the tests as a direct part of the design work (Madsen & Borgholm, 1999).

4.4 Cooperation between changing constellations of participants

As we see from following John, he cooperates with many people during his working day. He shifts between larger, preplanned meetings, and smaller ones, some of which are more ad hoc.

In planned meetings, it sometimes happens that participants bring artifacts to mediate the discussion. Often meetings take unexpected turns and the participants either have to continue without relevant artifacts or alternatively leave the meeting to pick up the needed materials.

Even though John was aware of the fact that he may later need to talk to the prototype designer, he often has no documentation of the process to bring along, and accordingly the lack of material outcome is indeed a severe problem, also when the constellations of participants changes.

In situations where the design collaboratorium room has been left untouched and notes taken, it would in some instances be useful for him to bring his new collaborators into the room, and in this way recapture the discussion. In other cases this is not possible, even when the room is left unchanged. In these cases, it is important for him to decide which notes to take and which documentation in general to bring away from the meeting.

Even when John has a plan of people to talk to in a given day, he often meet people in the hall, and it is difficult for John to anticipate whom he may end up working with, where and when. Accordingly John may need to carry vast quantities of notes and documentation around in a regular working day. This is unrealistic, and most often not done.

5 The interactive design collaboratorium

In order to address some of the challenges and conflicts in present design work, as identified above, we have prototyped an augmented environment for design work – an interactive design collaboratorium.

We have developed a room-sized prototype combined with a concept for how information and materials can be brought in and out of the room, and for shift between private and shared forms of information and materials. The room has interactive walls with rear projections, serving as enhanced whiteboards. It further contains a designer's workbench with a projection in the tabletop showing the projected workspaces either in 2D or 3D. The prototype takes advantage of the Open Hypermedia application "Manufaktur" (Büscher et al 1999) as

interface in the prototypes. This interface provides a link structure that supports users working with “live” documents and objects in a 3D environment where “workspaces” are used as a structuring mechanism.



Figure 3. The interactive design collaboratorium

Furthermore the application supports annotations. All interaction with the prototype applies an IR-pen and a wireless keyboard.

Through palmtops users can bring electronic link structures to and from the room, to be accessed on the palmtop or on walls and boards elsewhere. Objects can be moved between walls, the table and the personal palmtop.

The following scenarios were used in exploring how the interactive design collaboratorium would support and change the work in the usability design group. They match the 3 situations from John’s work described earlier.

Scenario 1

The common room is equipped with projection walls, an elevated meeting table and high stools. The group discusses holiday plans displayed on an interactive boards projected on the walls. The group moves on to brainstorm regarding a new project. The outcome of the brainstorm is added to the displayed workspace by taking notes, as on a whiteboard and additionally attaching these notes to the displayed documents. The interactive boards are used to sketch visions. While elaborating on the common ideas, each person also seeks to relate the visions to the parts they are responsible for. At some point, the implementation coordinator uses her palmtop to drag a list of component specifications onto the common board. She reminds everybody of the limitations of the components, and John makes a note on the board to check the recent developments in specifications. He does that by walking to the board and writing an

annotation on the specifications list. In order to develop some use scenarios, they look at pictures of past design, and agree on a couple that they want to keep as reminders for the continuation. John drags these to the current collection of documents, using the IR-pen. The scenarios get adjusted in light of the comment and the meeting ends up with a set of sketches of future scenarios on the boards. The technician drags the most problematic scenarios, as seen from her perspective, to her personal “to do” list. As the room is left, a snapshot of the walls is saved by John.

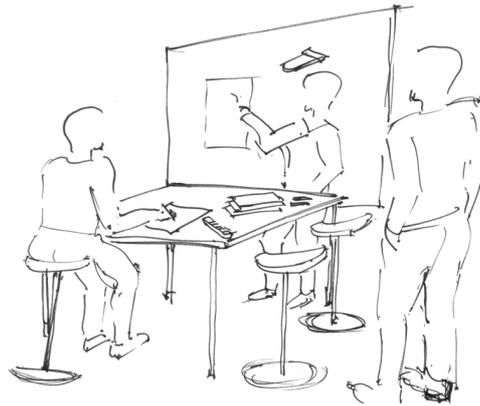


Figure 4. Scenario 1 - the common meeting

Scenario 2



Figure 5. Scenario 2 - the design session

When John later meets with the prototype developer, Brian, he uses his palmtop to drag the snapshot from the brainstorm meeting to Brian’s office board. Brian’s office is equipped with a projection board and a designer’s workbench table. John explains the visions and ideas which came up during the meeting. Brian asks questions and together they start sketch-

ing the prototype on the designer's workbench. They choose to look at one of the previous products in 3D to find out if it can be used as the basis for an early prototype. They retrieve a number of design documents that specify the menu structure of this past product, and they discuss if the prototype could be based on this same structure. Brian sketches a couple of alternatives as simple drawings directly on the workbench. John needs to leave, and Brian continue to work on the collection of documents.

Scenario 3

On his way to the next meeting, John passes his boss' office. Andrew, the boss, calls him in and points to his board, where a snapshot is projected. He tells John the latest news from a recent meeting. During this meeting they have come up with a suggestion which Andrew finds questionable and he asks John for advice. The problem reminds John of a discussions he has attended earlier in the day. Using his palmtop, he retrieves the relevant document from the brainstorm meeting and drags it to Andrews' workspace. Andrew keeps the new sketch on his board for further thoughts and discussions.

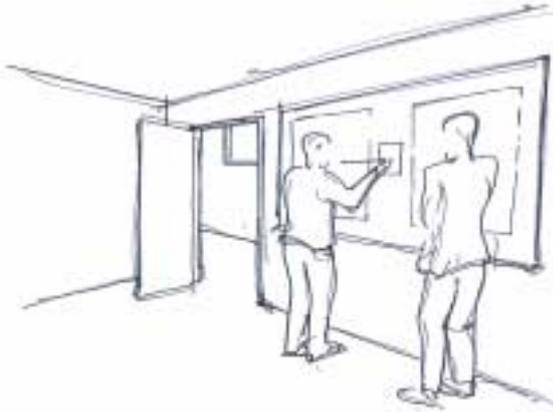


Figure 6. Scenario 3 - the ad hoc meeting

6 Evaluation with users

We evaluated scenarios 1 and 2 through a cooperative design workshop with the usability design group, whereas we have not yet evaluated scenario 3. Basically, the group held two of their scheduled meetings, reflecting scenarios 1 and 2, in the interactive design collaboratorium rather than at home. Project material had been incorporated in the prototypes in advance.

Working with scenario 1, the group of 5 people was to initiate a brainstorming session based on an electronic version of their own documents and make annotations capturing ideas and new connections between documents. The result of this session was to

be used in the next setting, addressing scenario 2. This scenario added the designer's workbench to the arrangement and included only two participants. The task was to refine and specialize the outcome of the brainstorm session.

Notes and documents were used extensively in both sessions to underpin issues raised in the discussions and to qualify design ideas. In this type of use, the participants tended to want to shuffle around documents by hand and gestures, whereas when drawing and writing the use of a pen-like physical device seemed more desirable.

The pool of project documents was seen as a powerful resource. It happened several times that participants opened new documents during the discussion to illustrate their opinions or to remind them selves of e.g. technical specifications or of strategic product scenarios. They argued that without this support, they would typically not have bothered to find the material, since the only alternative would be to leave the meeting to pick up material.

The lack of a personal notebook was seen as a problem in both settings. Writing in the notebook is often seen to signify to others that "this" is recorded and will be taken care of. The participants also requested an easy way of making personal notes public, e.g. by dragging them to the common space.

The physical setting in session 1 with extended stools, around a high positioned table was intended to encourage a lively activity and get everybody to step up to the wall. Apart from being puzzled by the novel arrangement of stools, table and wall at the beginning of the workshop, the participants adopted the setting fast and most of them went up to the wall to note down issues.

In session 2, the need for easy shifting of materials between the wall and the designer's workbench was identified. By intuition the designers placed the document they expected to modify on the tabletop, rather than on the wall. However, one of the documents placed on the wall ended up being central in their discussion, and they did not know how to move it to the tabletop for easy modification.

7 Requirements of the interactive design collaboratorium

The field studies, prototype experiments and user evaluation point to issues of consequence to our future work. First of all, we clearly identify the need for different ways of accumulating design knowledge:

Snapshots

To support the accumulation of design knowledge in individual design projects, the interactive design collaboratorium must provide a way of capturing snapshots of design meetings for later re-use. These must maintain the spatial layout of the documents to make it easy to reconstruct the document space for a subsequent meeting, or for the individual designer to return to earlier ideas and decisions.

Collections

As a different way of supporting the accumulation of design knowledge and inspire innovation, the interactive design collaboratorium must support individuals in selecting and saving (e.g. by transferring to the palmtop) the collection of documents that they need to keep or bring. Furthermore, such collections can be used by groups e.g. as a way of saving a collection of good ideas for later inspirational purposes or as a reflection of a particular use context.

Locales

Locales is a concept that deals with our concern for the physical organization of the room. It augments the concern for the spatial arrangement of documents by addressing the equally important physical objects and documents of the design situation. We make no assumption that a digital environment is better than physical objects and documents. Accordingly it is important that the interactive design collaboratorium supports the handling of physical artefacts, and at a later stage, that these can be tagged and traced as part of the set-up of the interactive design collaboratorium.

We have experimented with snapshots and collections and with ways of tagging and tracing physical objects. We have, however, not yet invented the magic wand that put the physical objects back in their place as part of the re-launching of a snapshot.

The case also illustrates how the primary concern must be with supporting people in actually creating joint design manifestations in the process, before there is anything (beyond spoken words) to share.

The requirements of the design collaboratorium can now be addressed in terms of "how to do it":

It accumulates design knowledge

The case shows how we need different types of support for accumulation of design knowledge (snapshots, collections and locales).

It reflects the use context

At present, the test facility living room is not well integrated in the design collaboratorium. We see a number of ways of resolving this. The test room could be equipped with interactive walls and

meetings could be held in the room, or the proposed video connection could be projected into the interactive workspace. Collections of images and documents of the use context is an additional possibility.

It inspires innovation

Personal collections play a role in inspiring innovation in that they provide means for the participants to present materials from their discipline and experience. Group collections similarly can evolve over themes like e.g. competitor products or a company "museum", and thus inspire the process.

The awareness created through persistent checklists and traces from other projects also serves to inspire innovation.

It supports open and closed cooperation between changing constellations of participants

The changing constellations of participants throughout a project, reinforces the need for materialization in terms of snapshots and collections.

Awareness of other participants is important. E.g. writing something in a notebook is an act of taking responsibility, and hence, not all writing is interesting for the substance as much as for the act. Accordingly, it is necessary to provide support for note-taking on the palmtop as alternative to writing on the board.

At a larger scale, leaving objects, checklists, etc. behind in the common room is a way of creating awareness between groups and projects, of what each other are doing. In the interactive design collaboratorium, this means that there is a need for persistent documents and objects, for things to be left behind, once a project meeting is wrapped up and saved.

One possibility is that certain areas and boards are reserved for e.g. inspiration rooms, where potentially relevant objects can be dragged whenever convenient. This is a way of using the spatial organization of the room without interfering with the actual working area of any particular project.

The research further poses additional requirements to the interactive design collaboratorium:

It supports mobility

Though Bang & Olufsen has built a design collaboratorium room, many design activities take place outside this room. Hence design activities take place in many physical locations, some ad hoc, and some in other locations, e.g. the test lab.

In the present case, everybody made use of personal notebooks to record and carry the thoughts and ideas that they found of use. And John in many instances prepared his trip around the building by collecting documents that he thought would be needed.

Despite this, he often had not brought what he needed. The palmtop solution helps him bring more stuff along as links to documents, to project on walls and boards in various places. Hence, snapshots and collections and not just of individual documents must be moveable.

It integrates the physical organization and the digital materials

In scenario 1, the spatial arrangement of digital documents and annotations were successfully supported by the physical organization of the room in terms of extended stools making it easy for participants to move to the wall to contribute to the materialization of design ideas.

Locales is a further concept that deals with our concern for the physical organization of the room.

An interesting prospect that we haven't yet dealt with is that of other locales than the common room. E.g. a meeting in the test room could put other requirements on the constellation of physical and virtual objects, and constellations could be kept to support later configurations of the room, where e.g. particular documents have been changed in between.

Based on a long-term cooperation with the usability design group at Bang & Olufsen we have further developed the vision of the design collaboratorium to take advantage of interactive room technologies. We have framed our findings in the concept of the interactive design collaboratorium, and in a set of requirements for this. We see this contribution as an important step in informing our own future experiments with interactive rooms, as well as valuable in informing general problems of interactive design rooms.

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