Does "roomware" matter ?

Investigating the role of personal and public information devices and their combination in meeting room collaboration

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Abstract: We report about an empirical study that investigates the role of different "roomware" configurations on the products and processes of meeting room collaboration. The configurations were realized by different combinations of providing computers and a large interactive electronic whiteboard. In this study, 48 subjects working in teams of four were assigned to three experimental conditions: four workstations networked and mounted in the table (WS), a LiveBoard (LB), and a networked combination of computers and LiveBoard (WS+LB). The results show that the teams in the WS+LB condition produced better quality work, in particular, generating more ideas than in the other two conditions. They also employed a more effective distribution of different cooperation modes.

1 Introduction

Research and development in the area of CSCW aims at the support of cooperation, communication and coordination of groups, but a large number of studies and development efforts in this field result in design decisions for software running on a computer on the desktop of an individual. The design focuses on what

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happens on the screen of this computer and how to interact with the software. Of course, the software supports multiple users and the interface has special cooperative features, but the desktop computer in an individual office is more or less the default situation. This trend is even increasing in the age of networked computer systems and Internet-based applications, where people do not have to be in one physical location in order to work together but can be distributed over multiple locations, in a multitude of individual offices. This way, people can share information and interact with one another although being apart. There are, of course and without any doubt, a number of serious advantages of software support for these settings bridging physical distances. We have worked and are still working ourselves in this area, e.g., on support for so called "virtual organizations" (Streitz, 1996; Johannsen et al., 1996).

The case of distributed cooperation settings covers only part of the full range of group work situations. We have argued before (Streitz, 1994) that comprehensive real world group activities involve all four combinations of the well-known same/different matrix of time and place and that system design should also address the transitions between different cooperation situations. For example, real face-to-face meetings (same time, same place) still play an important role, especially in the initial and later on often in critical phases of group work. Face-to-face meetings require a certain physical setting, usually a room which can accommodate all group members participating in the meeting. Beyond a certain size a traditional meeting room requires some furniture (tables, chairs, etc.) and some standard equipment (e.g., flipcharts, whiteboards, overhead projectors, etc.) providing the functionality needed to conduct meetings. It is known that the ergonomics of the physical design of these rooms including size and shape of the table, issues of lighting and acoustics, etc. are important for the quality of meetings.

Introducing computer-based technology into such a setting results in what has been called "electronic meeting rooms" (e.g., Nunamaker et al., 1991). It requires that the physical design of meeting rooms and the arrangement of equipment in the rooms have to be viewed from a new perspective. While the traditional ergonomic aspects are still important, one has to make new decisions on: which kind of computer equipment, how much of it, and where it should be positioned? Since computers are not the only type of equipment to be considered, we speak in general of "information devices", i.e. devices allowing information to be created, edited, and displayed. In order to have a term for the combination of information devices, furniture, walls, etc., we call the sum of these physical objects and their relationships constituting these settings "roomware".

We emphasize the general point that it is not sufficient to design only software when designing computer-based support for group work settings but that one has to pay equal attention to the roomware. We cannot discuss the role of all items making up the roomware in general in this paper. Instead, we will focus on those aspects relevant for the experiment reported in this paper.

In a face-to-face meeting situation, one can, in principle, distinguish between two kinds of "information devices" available to meeting participants:

- *personal devices*: these are usually available and visible only to one person. Examples are paper and pencil; paper documents brought along by a specific person; personal computers, notebooks, PDAs with documents in electronic form.
- *general/public devices*: these are used for displaying information so that it is visible to all people present in the room. Examples are whiteboards, the projection of transparencies via an overhead projector/slide projector, TV monitors showing video tapes or large screens for showing movies. Since some time, projection units are used for displaying the content of computer screens. Usually, they allow only to passively display information to the audience/participants. More recently, there are also devices which allow to interact with the displayed information using the hand or a cordless pen, modifying or creating new information. Examples are the Xerox Liveboard (Elrod et al., 1992) and the SMART Board (SMART Technology).

Different scenarios for electronic meeting rooms have employed different roomware configurations. For our purposes, we distinguish between three major configurations: networked computers only, large passive or interactive public displays, and the combination of these two sets of information devices. There are situations in which only or primarily networked personal computers are provided to the participants (e.g., Olson et al., 1993; Nunamaker et al., 1991), in most cases one computer for each participant. In other configurations, an additional large passive display is provided showing the content of one participant's window or a general public window. Examples are the CoLab (Stefik et al., 1987) and the CaptureLab (Mantei 1988). In some cases, the public display is operated by a moderator/facilitator (Nunamaker et al., 1995). Other scenarios provide an active large electronic whiteboard/blackboard. An early version is the electronic blackboard in the NICK experiment (Rein & Ellis, 1989). While the NICK experiment included also a condition which provided only workstations for the participants, there was no condition with a combination of all devices. Most scenarios involving interactive electronic whiteboards concentrate on providing and using only one large display (Pedersen et al., 1993) operated with a pen, sometimes additionally operated by a scribe using a notebook on the table (Moran et al., 1996). There is also the obvious but seldomly realized configuration of providing a large interactive display *and* personal computers to all participants and networking all devices with each other. This is the standard setup in our OCEAN-Lab at GMD-IPSI (see figure 1 in the description of the experiment). The functionality of the software used in the different scenarios differs also widely. It differs in the degree of and mechanisms for sharing information between different screens, the range of information types available (ascii text, scribbles, hypertext/media nodes and links, multimedia, etc.), and the types of interaction possible (keyboard/mouse-based,

pen-based, etc.). Since this experiment does not investigate and compare software features of meeting support systems, we do not elaborate this aspect.

People keep asking what really is necessary for setting up a computer-augmented meeting room - not only when they visit us and see the OCEAN-Lab configuration. There is no easy answer. Although there has been a lot of discussion for and against different roomware configurations, it is difficult to compare existing configurations because of many differences in other variables. There is - at least to our knowledge - no comparative study of defined roomware configurations with respect to information devices under controlled conditions, i.e. keeping the software, the task, the furniture, and the room constant. Therefore, we decided to design and run such an experiment comparing three different configurations. We will specify them in more detail when we describe the experimental conditions.

2 The Experiment

Based on the considerations in the introduction, we set out to investigate different roomware configurations. Our specific interest in this experiment was to focus on combinations of different *computer-based* information devices and keep other variables as constant as possible. Furthermore, in this experiment we do not compare computer-based information devices with non-computer-based devices such as traditional whiteboards/blackboards, overhead projectors or paper-and-pencil only.

2.1 Experimental questions and hypotheses

We had a number of hypotheses we wanted to investigate. One hypothesis was that the availability of personal devices for each group member would enable and increase the potential for individual and parallel work in subgroups. This should increase the number of ideas generated and have a positive impact on the quality of the final result. Another hypothesis was that the provision of a public device in the form of a large interactive whiteboard would provide a focus of attention for the group facilitating coordination and updating knowledge about information changes. A "public device only" condition should result in a more collective work style involving the whole group and less individual or parallel work phases. Finally, we expected that the combination of both personal and public devices would provide the group with the respective functionality to the benefit of the group. Thus, we had the hypothesis that the overall quality of the final result would be better than in the other two conditions. Of course, this would require that the group would be able to develop a work style which could make appropriate use of both types of devices in a complementary manner. This was an open question we could not answer beforehand and was therefore also a subject of the investigation.

In order to test our hypotheses, we needed a task and software with the potential that the group could actually develop different types of cooperation behavior.

Thus, the choice of the task was determined by the following requirements: It should be a realistic task and a situation which was easy for the subjects to identify with, at least in a role playing mode. It should have a clear objective but still be an open problem in the sense that there is not one definite answer or a predefined outcome. It should also be complex enough so that working on its solution could take advantage of the capabilities of the DOLPHIN software (Streitz et al., 1994) - we intended to use - which supports these different work styles.

2.2 Method

2.2.1 Setting

Since the experiment's goal was to investigate the effects of different configurations of personal and public devices, the setting was different in the experimental conditions. The experiment took place in our computer-augmented meeting room, the OCEAN-Lab. Figure 1 shows a picture of the OCEAN-Lab as it was used in the experiment. It shows the setting in the full WS+LB condition (see below). The papers used by the subjects in this picture are the task instructions and the software manual.

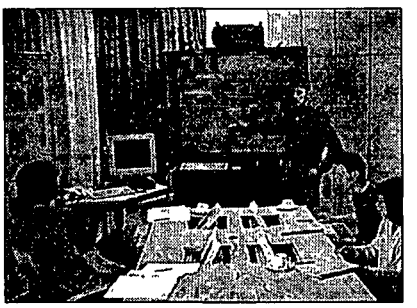

Figure 1. View of the OCEAN-Lab with the full WS+LB Condition

People were seated around a rectangular table (1,20 m x 2,80 m) and had different devices available, depending on which condition they were assigned to. The following information devices were available:

public device:

- a large interactive, electronic whiteboard was realized by a Xerox LiveBoard (LB) with a 67 inch color screen (back projection) and a cordless pen for directly interacting with the content on the screen while standing in front of it. A keyboard and a mouse was also available which could be placed on the table.

personal devices:

- four compact SUN Voyager workstations with flat 12 inch color LCD screens were integrated into the meeting room table and provided with keyboard and mouse. They were networked with each other and in the WS+LB condition (see below) also with the LiveBoard.
- paper and pencil

2.2.2 Experimental Design

In order to investigate the effects of different roomware configurations, a between-subjects design was used. Subjects worked in groups of four, with four groups in each of the three conditions resulting in a total of 48 subjects. Groups were assigned to the following three conditions as shown in Figure 2.

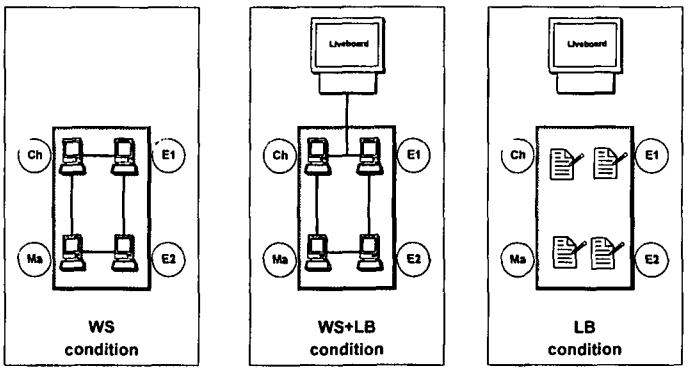

Figure 2. Schematic view of the three experimental roomware configurations

WS condition: Each member of the group was provided with an individual but networked compact workstation (WS) mounted in the table. The LiveBoard was not available. No paper and pencil was provided.

WS+LB condition: Here, the LiveBoard (LB) was added to and networked with the workstation configuration available in the WS condition. Subjects could work at their workstation but were also free to use the LiveBoard. The LiveBoard was available for everybody. No specific assignment of a person to the LiveBoard was made. No paper and pencil was provided.

LB condition: In this condition, the group had only the LiveBoard available. No specific assignment of a person to the LiveBoard was made. It was available for everybody. In addition, each member of the group was provided with a pencil and sheets of paper. (The workstations were not visible. They were hidden below the table. The holes were covered by fitting wood segments resulting in a table with a standard flat surface.)

Due to the table construction and the arrangement of the flat LCD screens of the mounted workstations, the group members had unobstructed views of each other also in the WS and WS+LB conditions. Thus, they were well able to see and talk to each other with no problems while using the computers. There were no relevant differences with respect to the visual and acoustic communication situation between the three conditions.

2.2.3 Task

The subjects were instructed to form a team which had the task of developing concepts and a proposal for the program of a new TV channel. The prospective new channel should specialize in families as its target group. The instructions for the team required two sets of activities. There was a global part which addressed the team as a whole and there were specific parts which specified the assignments of roles for each member of this team of four people. There were three different roles with the following responsibilities: One chairperson (Ch) supervising and coordinating the team, one marketing person (Ma) responsible for advertisement, PR activities, design of a logo, etc., and two editors (E1, E2) creating the content and the structure for the new program. The instructions recommended to organize the task as a project with the phases of brainstorming, assessment of ideas, elaboration and integration of ideas into a common proposal, and its final presentation based on the electronic document created during the project. The subjects were instructed to work through all phases but were free to decide the organizational and temporal arrangement on their own.

2.2.4 Software

We used the DOLPHIN cooperative hypermedia system (Streitz et al., 1994, Bapat et al., 1996) in the following ways: as a pen-based system on an interactive, electronic whiteboard and as a multi-user application shared between the networked computers and the LiveBoard.

DOLPHIN provides operations for creating, editing, selecting, moving, copying, pasting and deleting scribbles, text, geometrical objects (circles, lines, rectangles), hypermedia nodes and links. We explain the functionality of DOLPHIN available at the time of this experiment by describing different windows and elements of an example document with content from the experiment as shown in figure 3.

DOLHIN documents begin with a top node. Nodes consist of a title and a content which is called a page and displayed in a DOLPHIN window. The upper left window (labeled "Top Page") shows the group browser where all group members are currently working together. At the top of this window, the group members are represented by icons showing their face and name thus providing awareness information on who is currently sharing this content. Pages are composites that contain text elements, rectangles, nodes and links. Nodes are represented by gray boxes with a text label, e.g. "Image" or "Logo". Links connect different nodes. The content of the node "Logo" is displayed in a separate DOLPHIN window (the upper right window in figure 3). This window (labeled "Logo") contains some ideas and a sketch for the design of the signet for the Family TV channel. Users can create scribbles, text, nodes and links to other nodes. A scribble is a freehand writing or drawing such as the logo "F-TV".

DOLPHIN offers the possibility for users to work in parallel, either privately in an individual space or sharing a space with a subgroup. These spaces are separate nodes which can be viewed and edited in parallel to the public window (in

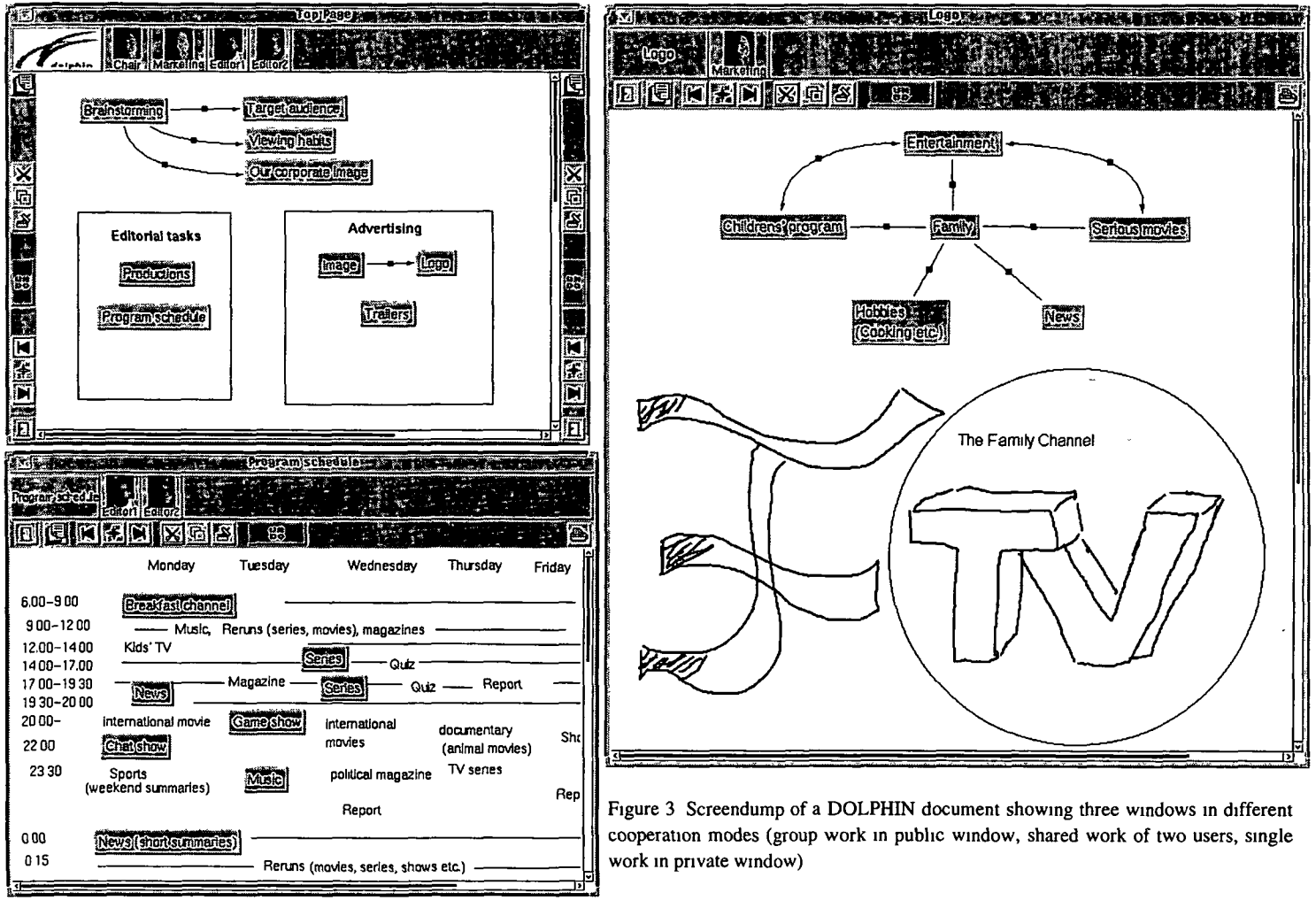

Figure 3 Screendump of a DOLPHIN document showing three windows in different cooperation modes (group work in public window, shared work of two users, single work in private window)

this example the Top Page). The bottom left window (labeled "Program schedule") shows an example for a shared session of the two editors working together. If a user wants to work privately, there is the alternative to open a node with a single session. The upper right window in which the marketing person is working on the page of the "Logo" node is an example of this. Within a shared workspace, DOLPHIN supports concurrent operations performed by different users. Shared access and active update/synchronization of concurrent DOLPHIN windows displaying the same node's content are provided by a cooperative hypermedia server. All changes to the DOLPHIN hypermedia document are reflected in the hypermedia server and made persistent.

Using the above types of objects and operations, users may create different structures, ranging from hierarchically nested structures, i.e. each node at a higher level of the hierarchy contains the nodes of the next lower level (thus forming tree-like structures) to nonlinear structures where nodes are included in the content of several other nodes (thus constituting nonlinear graph structures). The pen-based user interface of DOLPHIN provides gestures for creating, deleting, moving, and selecting objects as well as for opening a node's content. Further technical information on DOLPHIN can be found in (Streitz et al., 1994).

2.2.5 Subjects

The experiment took place between December 1995 and April 1996. A total of 48 subjects were recruited from students of the Technical University of Darmstadt. Their age varied between 19 and 24. There was the explicit requirement to have basic computer skills in order to participate in the experiment. These skills were primarily in the area of text processing, drawing programs, spreadsheets, and e-mail. No subject had prior experience with the DOLPHIN software or the task.

2.2.6 Procedure

All subjects received a 45-minute training session on the functionality of the DOLPHIN system. Subjects were shown examples of information structures on the LiveBoard and how to create and edit them using DOLPHIN. The training included a 15 minute period in which the subjects could practice on their own. After the training, the group started its work on the experimental task. The time of working on the experimental task was 4 hours, organized in two phases of 2 hours each separated by a lunch break of one hour.

2.2.7 The data collection infrastructure

Speaking time and cooperation time: The total view of the meeting room was videotaped. In order to differentiate how much time each subject spent speaking and how long he/she was engaged in different cooperation modes, we developed a new coding tool called COPROT. It was used for obtaining these times by viewing the video tapes. Figure 4 shows what its interface looks like. There are four categories for recording the speaking time by clicking on the buttons for the Chairman (Ch), the Marketing person (Ma), and the two Editors 1 (E1 and E2)

when this team member was speaking. In addition, there are 15 categories for different cooperation modes coded by selecting the icons at the bottom of the interface. For the different categories see section 2.2.8 on measures.

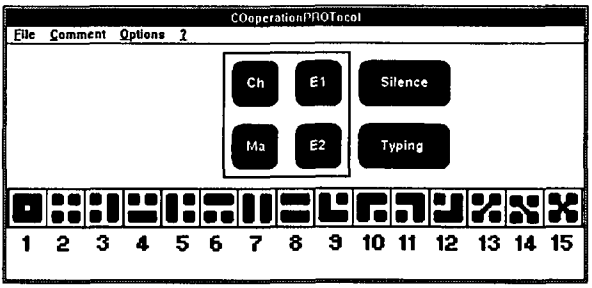

Figure 4: The interface of the COPROT-Tool with buttons for recording speaking time of team members (Ch, Ma, E1, E2) and recording different cooperation modes (1 to 15).

Logging of system interactions: All system interactions of the subjects with the DOLPHIN system at all four workstations and the LiveBoard were recorded in logfiles. This was possible by using a special version of the DOLPHIN software with a built-in logfile functionality. It allows recording each interaction and storing it in a data file, categorised and marked with a time stamp and information about the actor, time, location and if other users are in the same node at this time. The categories of the interactions are content production (typing, drawing), content structuring (moving, resizing, color change), navigation (opening nodes and windows) and hypertext operations (creating nodes/links).

Capturing of ideas on paper: In the LB condition, each subject was also provided with paper and pencil. In order to also obtain in this condition information on how ideas and concepts were generated and developed over time, we used stacks of paper sheets with carbon copy sheets in between. Subjects would always write on the top and keep this top sheet. Every thirty minutes, we removed sheets from below showing copies of the current state of the top sheet created by the carbon copy. Thus, we obtained 8 "snapshots" for each subject.

2.2.8 Measures and Coding

The choice of our measures was guided by the hypotheses and the design.

Qualitative measures: Two experts judged the overall quality of the final electronic documents created by each team. This was done separately. In a few cases, they resolved some differences afterwards in a common discussion. Criteria were the originality of ideas, quality of the information structure and quantitative aspects as, e.g., number of ideas. All documents were rank ordered by this quality measure.

Quantitative measures: Quantitative measures for assessing the production process of each team were obtained by using the data in the logfiles of the system interaction. This included interactions for navigation, for creation of hypermedia

nodes and links, text editing, and scribble creation. Furthermore, two experts counted how many ideas were generated. For the LB groups, the experts also counted the number of ideas created on paper.

Speaking times for each member of the team based on the COPROT data.

Time spent in different cooperation modes. This measure was obtained from the data recorded with the COPROT tool. Depending on the group size, there are many combinations of possible cooperation and communication patterns between the group members. In this experiment with four members, we distinguished between 15 different cooperation modes. The different combinations in which the members can communicate and cooperate are illustrated by the different icons (1 to 15) in figure 4.

A typical situation is cooperation mode 1. The group works together and all members have the same focus. In contrast to this is mode 2 which shows no cooperation. Nobody is speaking to anybody else. Everybody is working on a separate task. Cooperation modes 3 to 15 represent the different subgroup modes where one or more group members are working on their own separated from the rest of the group or two subgroups are working independently from another. For the particular evaluation reported in this paper, we clustered the 15 modes into the following three categories: "group mode" (= mode 1), "single mode" (= mode 2), and "subgroup mode" (= modes 3 to 15). There are more detailed analyses possible and interesting to look at but not within the limits of this paper.

Duration of individual work: In the cooperation modes "single" and "subgroup" some members are not communicating with the rest of the group. These subjects are engaged in individual work. We examined how much time is spent in a group in individual work vs. in collective work. This measure was derived from the coding of the time spent in different cooperation modes.

3 Results

The statistical procedures used in analyzing the data of this experiment were analysis of variance and t-test using a significance level of 1% or 5%.

The *overall quality of the teams' product* is measured by the quality of the proposal in terms of the final electronic document created by each team. As figure 5 shows, it differed significantly between the three conditions [$F(2,11)=7.52$, $p<0.05$]. The mean rank of the document quality was 7.63 in condition WS, 9.13 in condition WS+LB, and 2.75 in condition LB. The configurations WS+LB and WS are clearly superior to the LB only condition [$t(WS,LB) = 2.59$, $p<0.05$, $t(WS+LB,LB) = 5.01$, $p<0.01$].

Quantitative measures. While the overall quality of group work is a combined measure, the *number of ideas in the electronic documents* is a measure which can also be compared to other studies in the field. Figure 6 shows that it differed significantly between the three conditions [$F(2,11) = 5.52$, $p<0.05$]. The mean number of ideas created per group was: 251 in condition WS, 403 in condition

WS+LB, and 134.5 in condition LB. The WS+LB condition created the most and had the largest difference to the LB condition [t(WS+LB,LB) = 2.92, p<0.05].

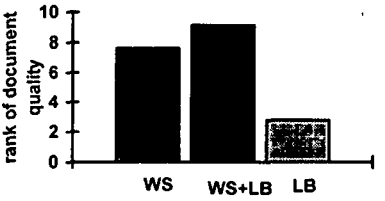

Figure 5 Mean ranks of document quality in the three experimental conditions

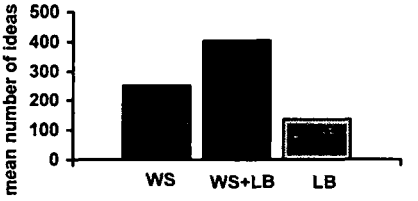

Figure 6. Mean number of ideas per group in the three conditions.

The groups in the LB condition had the possibility to generate ideas on paper before using them as part of the electronic document on the LiveBoard. Figure 7 shows the result of comparing the number of ideas on paper (mean = 350) with the number of ideas created per group as part of the electronic documents (mean = 134.5). One can see that the electronic documents contain only about one third of the number of ideas created on paper. These numbers do not refer to exclusive ideas, i.e., some ideas created on paper are also found in the electronic documents and vice versa. There were also ideas in the electronic documents which were combinations and/or modifications of ideas previously created on paper.

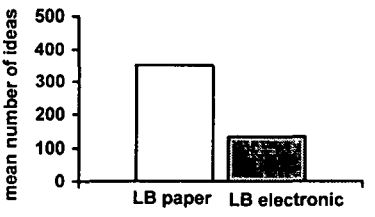

Figure 7 Number of ideas created on paper vs in the electronic document for the LB condition

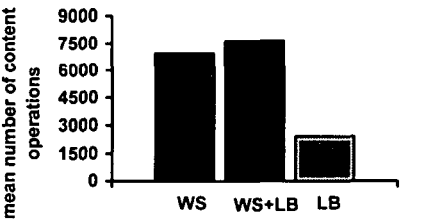

Figure 8. Mean number of content operations per group in the three conditions.

While the previous results are indicators for the final product, we now report some results on *variables reflecting the process*. One variable is the number of content operations which were detected by the logfile tool. The mean *number of content operations* per group was: 6953 in the WS condition, 7665.25 in the WS+LB condition, and 2435.5 in the LB condition. As one can see from figure 8, it differed significantly between the three conditions [F(2,11) = 7.73, p<0.05]. t(WS,LB) = 2.78, p<0.05. Again, the largest difference was between the WS+LB and the LB conditions [t(WS+LB,LB) = 5.43, p<0.01].

Since we expected differences in the modes of cooperation, we now report the *proportion of the time the group as a whole spent in one of the three cooperation modes* (defined in section 2.2.8). Figure 9 shows that the teams in the LB condition spent more time in "group mode" (69.4%) than the teams in the other conditions (57.8% and 64.3%) . This is mainly due to the differences in the time spent in the "single mode" (2.9% for LB vs. 9.5% and 17.9% respectively) while the proportion of activities in the "subgroup mode" is very similar.

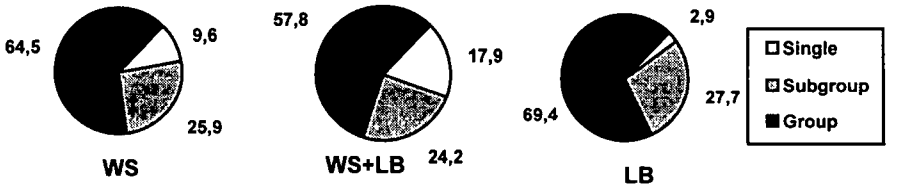

Figure 9· Relative proportion (%) of different cooperation modes. single, subgroup and group.

With our analysis tool, the different cooperation modes can be traced down to the behavior of the individual team member. Of special interest are differences between team members with different roles in the team. Figure 10 shows therefore the *duration of individual work for particular roles,* i.e. averaged over those members who had the same role and were in the same experimental condition.

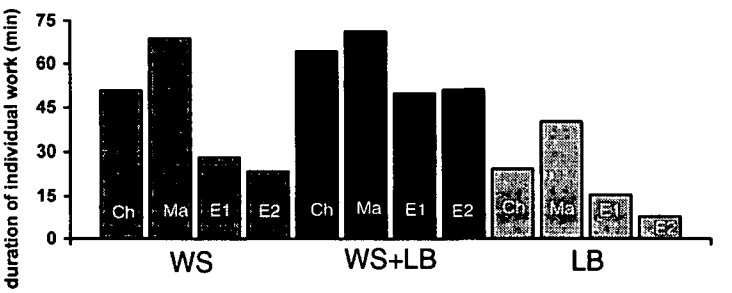

Figure 10 Duration of individual work for the roles: chairperson, marketing, editor1 and editor2.

Although there are significant differences between the conditions [$F(3,47) = 3.58$, $p<0.05$] with respect to the absolute time, there is a common pattern for the different roles irrespective of the conditions. Individual work is done especially by the marketing person (Ma) and also by the chairperson (Ch), while the two editors (E1, E2) work significantly less in this mode [t (Ma, E1) = 2.84 $p<0.01$; t(Ma, E2) = 2.85 $p<0.01$].

In figure 11, we now show the proportion of individual work with respect to the total time by distinguishing only between *individual work vs. collective work.*

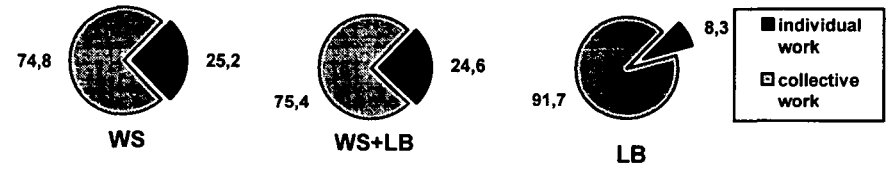

Figure 11: Proportion of time working alone vs working together with other group members

There are significant differences between the conditions [$F(2,11)= 3.94$, $p<0.01$]. The members of the LB teams spent less time in individual work situations than the WS and the WS+LB teams [$t(WS+LB,LB) = 3.32$, $p<0.05$]. In order to illustrate this result, we convert it in minutes. The members of the LB condition worked only less than 20 minutes alone while the WS teams and the WS+LB teams spent more than one hour working alone. For comparison: the total time of work in the experiment was 4 hours.

4 Discussion of results

The results of this experiment show that most of our hypotheses were confirmed or were pointing in the right direction. Those groups which were provided with a combination of both personal and public information devices, as realized in the WS+LB condition, produced higher quality products than the groups which had only one type of information device available. In particular, these groups produced significantly more ideas than the groups in the other conditions. With respect to the work process, the teams in the WS and WS+LB conditions had a similar high level of activity creating/editing content and were significantly more active than the teams in the LB condition. But in terms of number of ideas, the WS+LB teams did better than the WS teams. The availability of the LiveBoard provided a means for improving the elaboration and integration phase. It served the purpose of providing a focus for the discussion and coordination activities of the whole group. For example, it was used for the presentation of intermediary results.

With respect to the cooperation modes, the results show that the provision of both types of information devices was used by the WS+LB teams in an effective combination. On an average, they spent about half of their total time in the full group cooperation mode, and the other half in subgroups and in individual, single work The other groups, especially the LB teams, spent more time in the full group cooperation mode so that not much time was left for individual work. Comparing the results on the proportion of cooperation modes (figure 9) with the results on the overall quality measure (figure 5) one can see that these results are running parallel. The more single work - but still maintaining enough subgroup and full group activities - the better is the quality of the final product. This can be

explained by the following interpretation. Individual work is primarily used for generation of ideas and the number of ideas provides a major contribution to the overall quality measure. This is reflected in the correlation $r = 0.73$ ($p < 0.01$) we found between the cooperation mode single and the number of ideas generated computed over all groups and conditions.

The opportunity for individual activities (single mode), parallel activities (subgroup mode), and public activities (group mode) are mainly provided by the potential of the DOLPHIN software to work in these different modes. The hypermedia functionality provides nodes for private and public work spaces and the cooperative functionality means for sharing information. This is in line with previous results from an earlier experiment in which we investigated how hypermedia structures enabled parallel work and the division of labor (Mark et al., 1995; 1996).

One interesting way to look at the results is the following. One takes the full WS+LB condition as the starting point (these results are always in the middle of the figures 5 to 11). Looking to the left side (-> WS condition) one can see the effect of removing the LiveBoard from this roomware configuration. Looking to the right side (-> LB condition) one can see the effect of removing the networked workstations from this roomware configuration.

5 Conclusions and future work

There has been a large amount of work in CSCW that investigates the role of organizations, the social composition of work groups, the impact of situational factors on how to design multi-user information systems and appropriate interfaces supporting group work. We think that it is now time to look (again) at the physical settings and roomware variables of group work and its impact on products and processes of cooperation and communication. The reported experiment regarding different roomware configurations is one contribution to this direction.

In the future, we will extend this line of research in different directions. One direction is to design, build and investigate computer-augmented cooperation activity rooms populated by a variety of information devices ranging from very small to very large and being attentive, active, and adaptive (A^3-Rooms). This requires also new interaction paradigms and new visualization metaphors. Another direction is to provide the cooperation activities within the room with additional information sources: in terms of corporate memory knowledge, external world-wide available information or other people. The latter is a continuation of our work on distributed meeting rooms and ubiquitous meeting environments (Johannsen et al., 1996; Streitz, 1996). Here, we are coupling two or more meeting rooms via ATM networks and complementing the shared work spaces by conference control and high quality audio and video communication.

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