A Use of Drawing Surfaces in Different Collaborative Settings

Sara A. Bly
System Sciences Laboratory
Xerox Palo Alto Research Center
3333 Coyote Hill Road
Palo Alto, CA 94304

ABSTRACT

Two-person design sessions were studied in three different settings: face-to-face, geographically separated with an audio/video link, and a telephone-only connection. In all settings, the designers' uses of a drawing surface were noted. Many similar drawing surface activities occurred in all design settings even though the settings did not each allow for the same sharing and interaction with the drawing surfaces. Observations suggest that the process of creating drawings may be as important to the design process as the drawings themselves. These preliminary results raise issues for further study, particularly with respect to computer support for collaborative drawing surface use.

INTRODUCTION

The increase in the number of work groups that are distributed geographically has highlighted the need for computer tools to support remote collaborations. In addition to traditional telephone use, electronic mail and video-conferencing have made increased communication among distributed groups possible. One feature of many face-to-face collaborations is the use of a shared drawing surface (for example, a chalkboard or large pad of paper), and researchers are finding ways in which computers might support writing and drawing activities [1]. This paper reports on an exploratory study undertaken to begin characterizing the use of the drawing surface in face-to-face and remote work groups. It presents the drawing surface activities occurring in each of three sessions, observations on the effect and value of those activities, and issues for technological support of shared drawing in remote collaborations.

The study reported here was part of a research program to understand the use of audio/visual technologies to support remote collaborations. An experiment in supporting distributed work groups at the Xerox Palo Alto Research Center provided a *media link* between group members in Palo Alto, California, and their colleagues in Portland, Oregon [2, 3]. In addition to the usual telephones and computer networks, colleagues could see each other using a video connection of cameras, monitors, and video compression technology. The video signal was transmitted cross-site using a digital 56 Kbit/sec communications line that resulted in slow scan television resolution pictures with motion blur. Although individuals using computer workstations could share screen images in their collaborations, they also needed drawing spaces that could be shared in cross-site design sessions.

STUDY

Two specific goals of the study reported here grew out of the need to provide shared drawing spaces as part of the media link. These goals are to begin characterizing the activities that occur in a drawing space and to identify those activities occurring in remote collaborative settings that might be improved with technology. The intent was not to compare a face-to-face setting with geographically distributed settings but rather to begin to understand the use of drawing spaces for design in different settings.

In the remote settings, the designers were able to communicate using the media link or telephone only. I expected that the designers would have great difficulty accomplishing tasks in the geographically distributed settings and that this difficulty would offer initial ideas about the areas of support most needed. Certainly the designers did feel that the media link and telephone sessions lacked the close communication and shared drawing of the face-to-face session. However, all three tasks were

completed successfully, and the drawing surface continued to be used in each setting. These results raise questions for further study in understanding drawing surface activities and how those activities might be better supported.

Study Set-Up

I set up the study so that I would work with a colleague with whom I had collaborated on several projects previously. The study consisted of three two-person design sessions, each separated by a week and each in a different setting. Each design session for the study centered on a different user interface problem that was part of a larger office workstation application familiar to both of us. The study tasks themselves involved no new graphic design, but rather extensions of existing user interface mechanisms. Each task was completed in at most an hour and a half and resulted in a short design specification describing the design decision. The three settings were *face-to-face*, across the *media link*, and by *telephone*.

For the face-to-face session, we worked in our usual manner at a small table with a large drawing pad. This allowed us to share verbal and visual information fully. We were both experienced in working in this setting.

For the media link session, we were separated geographically and had somewhat degraded visual information: the slow scan television caused visual information to lag behind the verbal information, the picture blurred whenever motion occurred, there was no means for sharing the other's drawing space, and we each had to look up at a monitor (away from our own drawing surfaces) in order to see the other's drawing surface. Furthermore, while one of us was very experienced in using the media link, neither was accustomed to designing in this setting.

Figure 1 illustrates the set-up, similar to a previous study of designers working via a media link [4]. Each of us was seated at a table with a large drawing pad. Two cameras were used at each site. One camera focused on a frontal face view of the designer and one on the drawing surface. Each designer had one monitor (that included a small inset view) displaying the two camera views from the remote location. Figure 2 illustrates the way in which I saw my colleague across the media link. Here, her drawing surface is full screen and her face is in the small inset. We could each switch the contents of the full view and inset view between the face and drawing surface. We used telephone headphones for the audio connection.

For the final session, we used the telephone as our only means of communication. As in the media link session, we each sat at a small table with a large drawing pad. Cameras were set-up to record the proceedings, but not to provide a visual link between us. The telephone session provided a familiar means of verbal communication but did not allow any visual sharing.

Each session was videotaped for later analysis. Also, after each session was completed, we separately recorded our reflections on the design session.

Study Data

Using the videotapes, I watched each session to gain an overall view of that session and to record a timeline of design flow, noting shifts among task topics, administrative issues, and social comments. I then used the videotapes to create a log of drawing surface events. I referred to distinct groups of sketches and pieces of text on the drawing surface as *drawing clusters*. An event was a continuous action during which the drawing tool or pointer was not removed from the drawing cluster. An event entry in the log consists of the action (drawing, writing, or gesturing), the time the action took place, the drawing cluster acted upon, the observed purpose for the action, the actor, and the speaker. Often the conversation and designers' attention would move rapidly among different ideas, so that it might take several events to complete a drawing cluster. Similarly the designers often reused or referred back to a drawing cluster after subsequent drawing clusters had been created.

I considered four aspects of the data and their possible significance to the design activity.[1] First, the *actions* themselves indicate what the designers did during the collaboration. Second, the *uses* of the actions help determine the role of the drawing surface in the collaboration. Third, the *interactions* on drawing clusters offer information on the shared nature of a drawing surface. Fourth, the designers' *reactions* to the various sessions suggest how effective they felt in the various settings. A preliminary analysis of this data suggests that the drawing activities (the actions and their uses) might be as important to collaborative design work as the resulting artifacts (the marks on paper comprising drawing clusters).

1 The face-to-face session lasted approximately an hour; 48 minutes were directly related to the task topic. The media link and telephone sessions each lasted approximately an hour and a half; 66 minutes and 72 minutes respectively were directly related to the task topic.

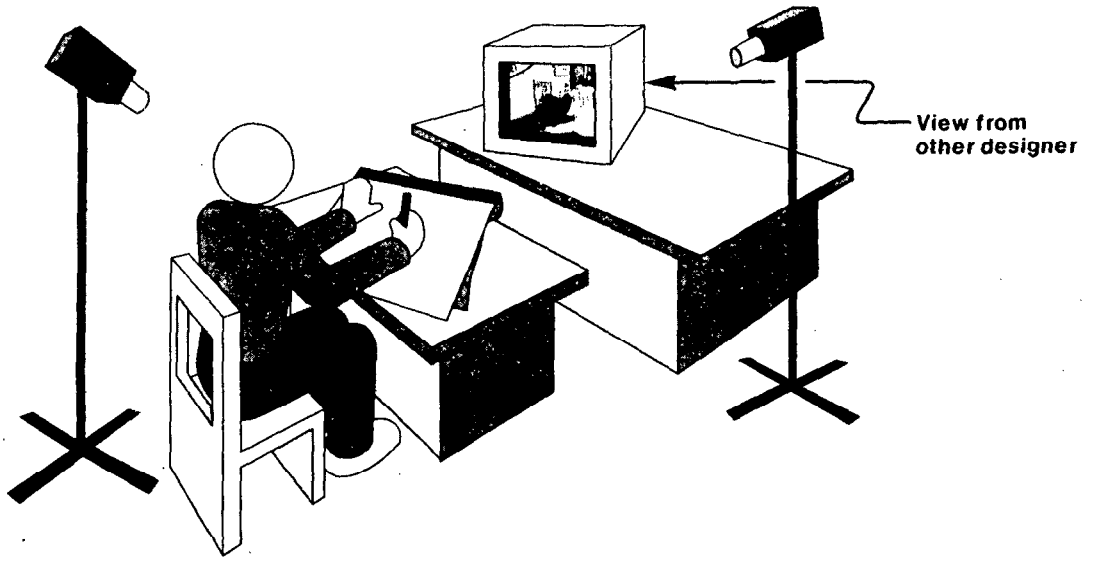


Figure 1: The media link room had two cameras and a monitor for visual communication.

Actions. I divided actions into three categories: a *draw* action was a graphic mark on the paper, a *write* action was a text or alphanumeric mark on the paper, and a *gesture* action was a motion specifically related to an existing mark on the paper. Gestures were not included in the log if they did not point to or make use of an existing mark.[2] Table 1 shows the number of actions taken by each participant during each design session.

[2] Note that the number of gestures logged is actually lower than the number of gestures that actually occurred in each session since many gestures were made that did not directly relate to a particular mark.

In the two sessions providing visual contact, gestures constituted a significant portion of the drawing actions that took place. Because gestures are temporary and add to the conversation of the moment, their importance can not be based on producing an artifact but on adding content to the discussion. Gestures allowed the designers to act out a sequence of user actions illustrating a mechanism and to point to a drawing cluster as reference or emphasis to objects and ideas. Many gestures occurred even when the designers were not able to see them clearly via the media link (or not at all in the telephone session) indicating that they may

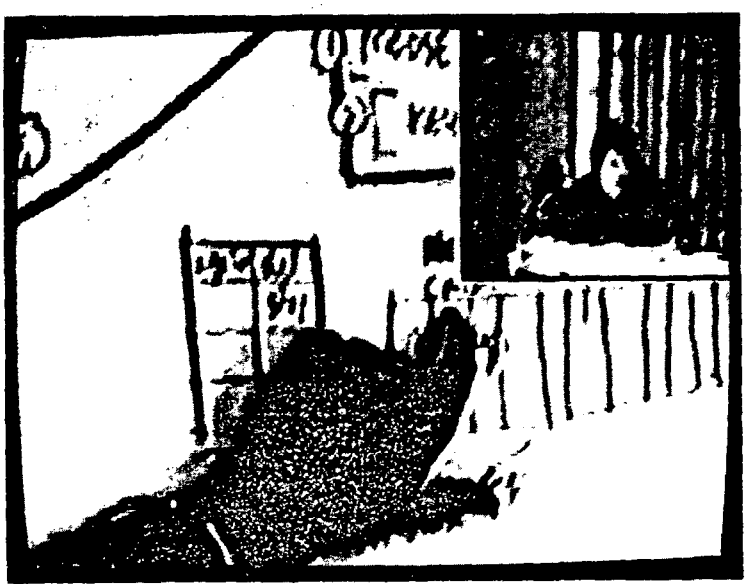
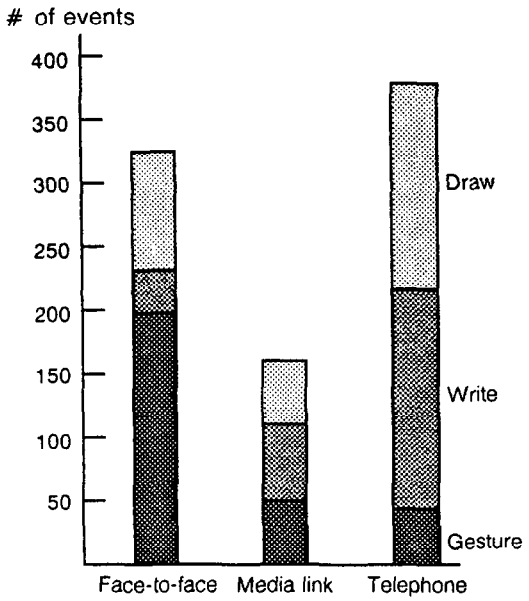


Figure 2: A view across the media link contained both the designer's face and the drawing surface.



	Face-to-Face		Media Link		Telephone	
Draw	93	29%	50	31%	164	43%
Write	35	11%	61	38%	173	46%
Gesture	197	61%	50	31%	43	11%
Total:	325		161		380	

Table 1: The number of drawing surface actions for each session.

have use to the individual as well as to the other collaborator.

Uses. From observing the session videotapes, I categorized the ways in which actions were used. I then marked each event as being primarily an *illustration*, an *emphasis*, a *note*, a *reference*, or other.

- An *illustration* is an action that visually adds new information to the discussion. An example of an illustration is a designer drawing two objects to show the relationship of one to the other.
- An *emphasis* is an action that visually provides redundant information to the talk. An example of an emphasis is a designer underlining a previously drawn rectangle while making a statement about "a rectangle".
- A *note* is an action that visually provides a reminder or permanent record of the discussion. Listing the options for exiting a command is an example of a note.
- A *reference* is an action that visually provides a replacement for verbal information. Pointing to a previously drawn command key and saying "do that" is an example of a reference.
- Other actions include doodles, lines separating areas on the page, etc.

In most cases, any of the actions could be used to accomplish any of the uses. Many times the actions

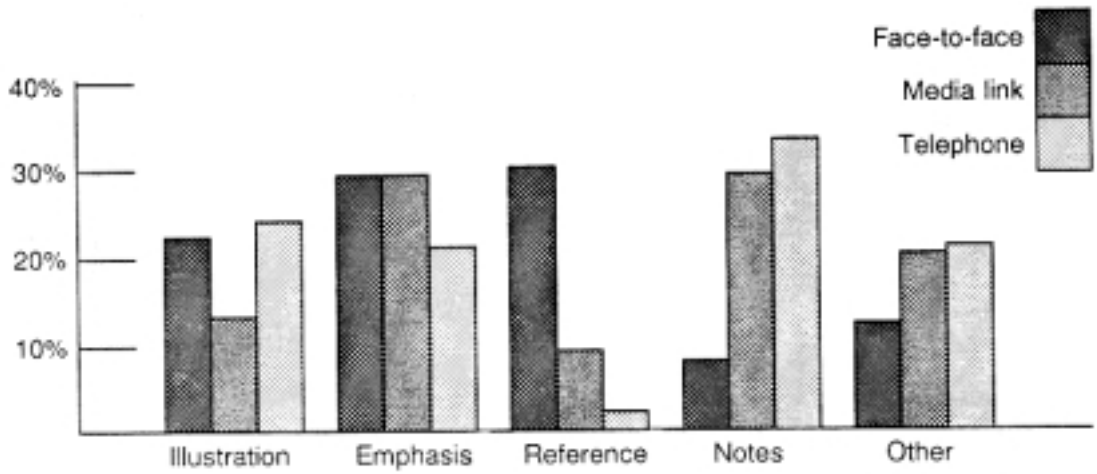


Figure 3: The percent of each of the uses of the drawing surface by session.

served more than one purpose. For example, an illustration might also serve as an emphasis to the discussion. I marked the primary use of the action; Figure 3 shows the relative percentage of uses that occurred in each session.

In all sessions, the use of the drawing surface actions to provide emphasis to the discussion occurred frequently. The use of drawing actions for emphasis did not add new information but rather punctuated the talk. These events seemed important as a means of focusing attention and helping the speaker express ideas. References were a frequent use of the drawing surface in the face-to-face session and understandably decreased in use as the visual bandwidth decreased in the media link (finally falling off almost entirely in the telephone session). Like emphasis, this use does not add new information to the discussion. However, references provide a short-cut to a previous object or concept, perhaps focusing the listener's attention as well.

It's interesting to note that the relative amount of note-taking increased substantially as the designers grew farther apart. I suspect that as the number of visual clues and redundant information in the discussion decreased, the designers used notes both as reminders and as a means of focusing their own attention on the content of the discussion. This is especially true in the telephone session.

The fact that a large number of illustration events were logged in the telephone session suggests that the designers were attempting to supplement the verbal communication. Often the same drawings were produced by the two designers. Using their knowledge of the task and the verbal discussion, the designers were able to pull ideas together in drawings and writings.

The categorization of uses defined here is too simple to explain fully the use of drawing surfaces. For example, as the designers became farther apart, the distinction between illustrations and notes became more difficult to determine. In the media link session, Designer A produced several *other* events by drawing graphic elements that structured the drawing surface, such as boundary lines around areas. In the telephone session, Designer B spent a great deal of time doodling, primarily drawing over marks already on the page. These variations in use raise questions not only about drawing surface activities but also about the possibly different roles the drawing surface may play in different settings.

Interactions. During the face-to-face design session, we were able to mark and gesture on drawings started by the other. Figure 4 illustrates the interaction on each of the drawing clusters and the number of events related to each of those clusters. The number of events is separated by designer so that the bars in figure 4 indicate whether one or both designers acted on each of the drawing clusters created in this session. (The drawing clusters are numbered in the order of initial creation though not all events on a drawing cluster occurred before the next cluster was started.) For example, cluster #1 was used by both Designers A and B while cluster #2 was used only by Designer A.

Almost half of the drawing clusters were used by *both* designers (18/37 or 49%). Also note that most of the drawing events occurred on these shared clusters; the 18 shared clusters accounted for 254 (78%) of the drawing events. In addition, 80 events (25% of the total) were actions taken by one designer on a drawing cluster initially created by the other designer. This data indicates that these designers took full advantage of the ability to modify

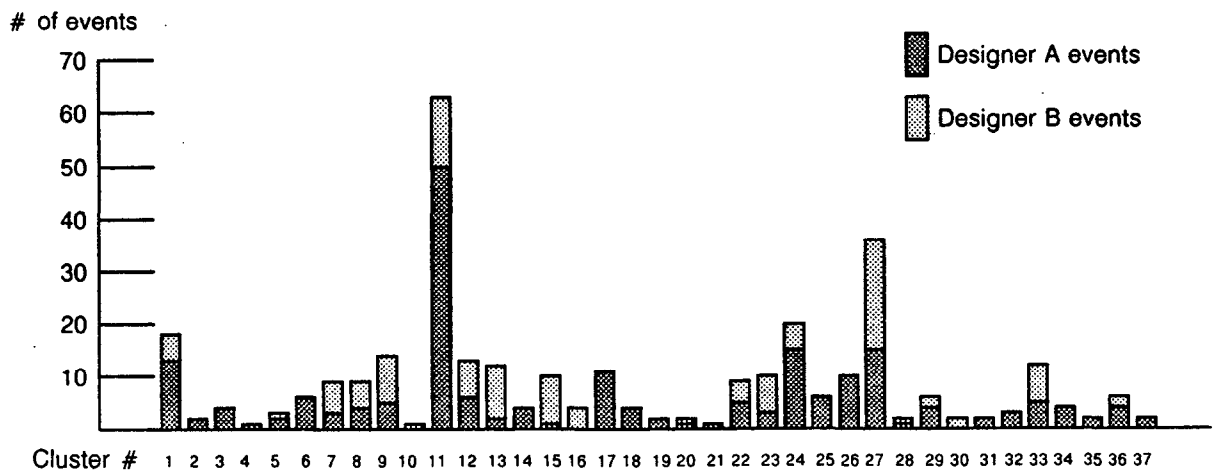


Figure 4: In the face-to-face session, many interactions occurred on shared clusters.

and use each other's drawing clusters. The fact that shared drawings accounted for most of the drawing events suggests that these clusters played a key role in the design session.

Reactions. After each session, the designers individually recorded their feelings about the design session setting and what they were able to do or wished to do. We specifically addressed the following questions:

1. What did I want to do that I was not able to do?
2. What do I feel was accomplished in this design session?
3. How do I feel about the interaction?

Following are representative phrases from the follow-up statements of my colleague:

Face-to-face:

"having this big piece of paper to work with and talk over kept there from being any lag time, kept there from being a lack of understanding 'cause we could work with what we were drawing as we were talking about it"

Media link:

"I miss (being) able to share the same writing space, ...being able to write on each others' designs"

"there's a little more distance in the interaction"

"both work(ing) on a paper space did a lot in being able to bridge the distance and being able to do it dynamically"

Telephone:

"What did I want to do that I was not able to do? DRAW PICTURES TOGETHER."

"I would have liked to have seen what she was doing"

"needs a lot more imagination and memory"

Not unexpectedly in follow-up discussions, the designers said they felt farther apart during the media link and telephone sessions and that their feelings of "energy" decreased.[3] The fact that they were not able to interact directly with each other's drawings, that gestures were not as frequent, and that references were more difficult are likely factors contributing to the perceived distance. It appears that in addition to the artifacts on the surface itself, the activity around the drawing surface is a means of focusing attention, of drawing the collaborators together, and of aiding in expressing ideas. Thus, the more the designers are able to share their use of the drawing surface, the more energy they feel in the design session.

3. The designers used "energy" to refer to their enthusiasm for the task and the interaction, for their ability to concentrate on the design, and for their interest in the session.

General Observations. Because I strictly differentiated between drawing and writing, the creation of a drawing cluster containing both text and graphics often required logging many events. As the designer drew a part of a graphic, then annotated that graphic, and then continued to draw, I logged separate events for each. Often these events were only one or two seconds apart; that is, the designer rapidly switched between drawing and writing. It's interesting to note that few, if any, existing computer-supported sketching tools allow such rapid transitions. This limitation could be a detriment to computer-supported design sessions.

All three of the sessions were successful in that designs were found for each of the three user interface problems. However, the designer reactions indicated that they felt less effective as the means of communication became more limited. Undoubtedly, the experiences that the designers had working face-to-face contributed to their success in the remote settings. These settings should be used and studied over time to determine whether or not the uses of the drawing surface change and how support of interactive drawing surfaces can contribute to effective design sessions.

The data is limited in that it comes from a single two-person design team of which I was a member. Additionally, our tasks were short, were based on mechanisms well-known by both of us, and were varied. One would expect to see somewhat different uses of drawing surfaces as the design teams differ in size, task, and personnel. Nevertheless, the results offer insight into more effective use of a media link for remote collaborations, capabilities to be included in computer-supported remote drawing surfaces, and issues for further study.

SUGGESTIONS FOR FURTHER RESEARCH

Are drawing activities significant to design collaborations? The fact that this and other studies [5] indicate that designers use the drawing surface extensively as part of the collaborative design process suggests that the drawing activities themselves may be important, even independent of the drawing artifacts created. These activities appear to pull the designers together, contribute to their verbal communication, and increase their focus on the design issues. It is appropriate to ask whether the results generalize across different design tasks and different collaborative groups. If so, we should consider whether drawing surface activities are relevant to the success of the design process. I pose the following hypotheses:

- The actions, uses, and interactions on a drawing artifact are as important to the effectiveness of

many design collaborations as viewing the final artifact.

- Allowing designers to share drawing space activities increases their attention and involvement in the design task.

Certainly further research is needed to understand the role of drawing space activities in the design process and how that might be accommodated by computer-supported collaborative drawing tools.

ACKNOWLEDGEMENTS

I very much appreciate the support for this work by my colleagues, particularly from John Tang for numerous discussions and insights, from Susan Irwin, Scott Minneman, and Jane Laursen who helped with set-up, from members of the Interaction Analysis Lab for comments on the videotapes, from Debbie Tatar for comments on paper drafts, and from Margi Olsen and Jarrett Rosenberg for study suggestions. I especially thank my collaborator, Janaia Donaldson, for her willingness to bring familiar work into unfamiliar settings and whose spirit keeps us going in any environment.

REFERENCES

1. Stefik, M., Foster, G., Bobrow, D., Kahn, K., Lanning, S., and Suchman, L. "Beyond the Chalkboard: Computer Support for Collaboration and Problem Solving in Meetings", *Communications of the ACM 30*, 1 (Jan. 1987).
2. Stults, R., *Media Space*, Xerox PARC technical report, 1986.
3. Goodman, G., and Abel, M. "Collaboration Research in SCL", *Proceedings of the Conference on Computer-Supported Cooperative Work*, Austin, TX (Dec. 1986).
4. Stults, R., "The Office Design Project, an experimental use of a media space", report in progress, 1988.
5. Tang, J., and Leifer, L. "A Framework for Understanding the Workspace Activity of Design Teams", *Proceedings of the Second Conference on Computer-Supported Cooperative Work*, Portland, OR (Sept. 1988).