Encouraging Contribution to Shared Sketches in Brainstorming Meetings

Abstract
Current brainstorming in small design groups typically involves primarily one person taking notes and sketching at a whiteboard while other group members remain seated and verbally contribute. We designed a collaborative sketching tool that supports simultaneous contribution and viewing of the same canvas through individual inputs and a digital whiteboard with the goal of lowering the threshold for shared sketching and supporting collaboration. A pilot study indicates that our system helps equalize sketching contribution within a group but also reduces total sketching input of the group. Initial findings suggest that personal inputs to a shared sketching space has interesting implications for brainstorming such as greater awareness of individual contribution levels and increased consciousness of the quality of sketches shared with the group.

Keywords
Design meetings, brainstorming, sketching, Tablet PC, digital whiteboard.

ACM Classification Keywords
H.5.3: Group and Organization Interfaces: Computer-supported cooperative work, H.5.2: User Interfaces: input devices and strategies; Interaction style.
Introduction

Group brainstorming in small, collocated, synchronous meetings is an integral part of the design process. Typically, one team member will act as a facilitator and take notes on a whiteboard to support the group discussion. Research shows that sketching contributes to the process of idea development and expression and to group communication [5]. Sketching supports re-interpretive thinking cycles, re-interpretation of each other’s ideas, and access to earlier ideas [6]. The other team members typically sit oriented toward the whiteboard with individual logbooks for taking personal notes. The whiteboard, a large shared display, plays an important role in mediating the group interaction by focusing attention.

From observation and our own experience, we assert that current whiteboard practice does not well support shared multi-person drawing during group meetings. Research indicates there is a need for concurrent access to the drawing space in collaborative group meetings [5]. However, simultaneously working on the same sketch at the whiteboard is awkward because people must stand close together and often get in each other’s way, and it is physically impossible to work in the exact same location on the board.

Furthermore, we observed that those seated usually do not stand up and approach the whiteboard. We believe this is due to the physical effort and time involved. In many cases, when a verbally expressed idea is not understood, seated team members must be explicitly asked to draw their idea on the whiteboard. The result is that primarily one person writes to the whiteboard during brainstorming, instilling an inherent bias to what gets recorded and how it is recorded.

Figure 2. Our collaborative sketching tool affords simultaneous input and viewing of a shared sketching space (below) through networked Tablet PCs and a digital whiteboard (above).

Digital whiteboards bring the benefits of digital technology to the traditional whiteboard interface, such as automatic documentation and display of images. Use of standalone digital whiteboards during meetings typically follow the interaction patterns noted.

We designed a collaborative sketching tool that allows multiple users to simultaneously contribute to the same canvas through individual inputs. The system includes Tablet PCs for each group member and a digital whiteboard, a large shared display, for the group. All the devices support a networked sketching program, so each group member can each easily view and add to the same shared sketching space. We believe equal access to view and input to the public space lowers the threshold for shared sketching and that collocated input and display will further support collaboration.

Related Work

Rekimoto investigated a multiple-device input to a digital whiteboard system for supporting meetings [4]. His initial goal was to address user interface issues of Tivoli, one of the first collaborative software systems for digital whiteboards, by distributing some of the whiteboard functions to a PDA. Rekimoto’s work evidenced the benefit of a digitally augmented whiteboards (facilitating content manipulation and layout) and provides useful insights about issues with individual user control of the whiteboard display, user identification, and gestural input. The hardware involved is similar to ours as it uses multiple devices to input to a digital whiteboard. However, the personal devices in Rekimoto’s system function as toolboxes, “an artist’s palette,” while our system positions the Tablet PCs as the primary sketching editor while the whiteboard’s role is more as a group visual focus.
Rekimoto emphasizes the Pick-and-Drop interface (a physical metaphor for transferring content between devices) while our tool emphasizes direct manipulation of the digital whiteboard without requiring the user to physically approach it.

PebblesDraw is a multi-cursor drawing program in a Single Display Groupware application that links simultaneous input from Personal Digital Assistants (PDAs) to a single PC display [2]. The envisioned use of the system allows multiple users to create and annotate drawings at the same time. Various issues arise from having a single shared display that supports independent users’ actions, e.g. sharing a single tool palette, identification of individual selection handles, and menus obscuring space others are working on.

Livenotes, a shared whiteboard system for group annotation of lecture slides during class, also utilizes a networked digital whiteboard and individual Tablet PC inputs [1]. The system’s purpose is to facilitate learning during lecture. Their user study found that the cooperative system led to notes with more comprehensive coverage of lecture material, a richer variety of whiteboard activity, and increased discussion participation.

Olson, et al. investigated how use of a simple shared text editor, ShrEdit, affected the process of design meetings and their outcomes [3]. In their user study, in one condition each participant had their own computer (recessed in a conference table) with a group editor that allowed everyone to see and edit the same document simultaneously while the control condition used conventional meeting tools. The study found that those using the tool explored less of the design space as it helped them focus on core issues of the designs. The breadth of ideas produced was reduced while the depth was increased.

System Description
Our program is a networked sketching tool. Drawing on any device in the system appears on all other devices in the system, supporting collaborative sketching in a shared public space. The system allows freehand sketching and erasing that can vary in color and thickness. Freeform selection allows strokes to be moved within the page. A user’s cursor, identified with their login, appears in the shared view when they draw, select, or erase. Additionally, gesture is supported with a hand tool. The system supports an unlimited number of pages, and navigation between old and new pages affects all users, keeping the group literally “on the same page.” The interface is the same when run on Tablet PCs and a digital whiteboard.

We developed the application from the ground up using Java 1.5. Using a client-server network architecture, our system synchronizes computers by streaming sketching information in real-time over TCP/IP. All interaction with the program is streamed through the server, allowing it to be logged.

Evaluation
We hypothesize that in a group brainstorming session, a shared sketching space accessed and viewed through networked personal devices and a digital whiteboard will increase the total amount of sketching by the group and equalize individual participation within the group because the system lowers the threshold for contribution.
To evaluate our hypothesis we performed a pilot study with groups of HCI and ME design students from Stanford University. Our study took place in the Stanford iRoom, where groups of three students were given Tablet PCs and a touch screen digital whiteboard. In the experimental condition, the devices were networked and acted as a shared drawing surface. In the control condition, the devices were isolated and acted as independent drawing surfaces, similar to conventional tools that support group meetings. We performed a between subjects experiment with five groups of three design students in each condition.

During the study, we first introduced the participants to the program and digital tools and gave them five-to-ten minutes to familiarize themselves with them. The groups were then given 30 minutes to brainstorm a design for a multi-function remote controller for a stove, oven, and stereo and instructed to present their final design in one-to-two minutes at the end of the session. The task was based on one used in prior research of collaborative small design group activity. Participants then filled out a post-study questionnaire that consisted of 20 five-point Likert scale questions and six free-form questions related to usefulness of the system for task completion and communication, group participation and dynamics, and brainstorming strategies. We then debriefed the participants and informally interviewed them about the experience.

The server application collected performance data through recording a log file of every stroke input on each device.

### Results and Discussion

The stroke data collected indicates that sketching contribution among group members was more equal in the experimental condition. The average standard deviation within a group of the percentage of strokes per user was smaller in the experimental condition (p-value = 0.165). Contrary to our initial hypothesis, the stroke data indicates that the total sketching input of the control groups was greater than the experimental groups (p-value = 0.21).

Most of the control groups followed the typical design meeting whiteboard practice with a self-appointed notetaker being the primary user of the digital whiteboard and the seated group members using the Tablet PCs occasionally for private sketching that sometimes they would subsequently share with the group. In contrast, the experimental groups seldom approached the whiteboard. On average, 57% of total strokes in the control groups were input on the whiteboard as opposed to 4.4% of strokes in the experimental groups (p-value = 0.007). Answers to the free-form questions and our informal interviews indicate that the digital whiteboard in the experimental condition was primarily used for viewing and group focus as it felt like it "tied everything together" and was better for seeing what everyone was doing despite showing the same view as the Tablet PCs. Participants said that they liked not having to get up to use the whiteboard. One group also mentioned that given the individual devices, the whiteboard seemed to "hold more power," which discouraged them from using it.

Participants commented that the collaborative system, compared to traditional tools, made much more obvious and explicit who was contributing. It appears that
individual sketching contribution as opposed to verbal contributions that another group member sketches results in users feeling very differently about adding to the shared visual space. Participants noted that with the system, they were more conscious of how much each person contributed, and in some cases moderated how much they sketched as a result. One group embraced this aspect and decided to use color to indicate sketch ownership. Furthermore, some participants told us that they were more self-conscious of the quality of the ideas that they added to the shared visual display, for example, that they felt an “implicit responsibility” for what they added to be a real contribution. Some participants said that they thought longer about ideas to make them more complete before proposing them to the group with a sketch.

This greater consciousness of quality and quantity of contribution, resulting in moderation of sketches added to the shared space, potentially explains why total sketching contribution was less in the experimental condition. We speculate that this increased awareness could be due to a more explicit identification of who contributes what (through watching the process of sketching as well as resulting sketches being identifiable) or to the fact that sketching, which creates a visual artifact, is a more formal contribution than verbal expression.

We observed in the experimental condition interactive collaborative sketching. Group members would build off each other’s drawings by annotating an existing sketch or drawing an alternative idea next to it. In one group, all three members contributed to a list of ideas, adding items individually. In other experimental groups, a notetaker naturally emerged who recorded text information, but all participants contributed drawings.

Participants noted that they liked being able to sketch an idea while someone else was speaking or drawing. With conventional tools, a second person approaching the whiteboard would demand group focus. Drawing with our system allowed people to get down their idea in a less obtrusive manner, with one participant describing it as a way to “raise your hand.”

One current drawback of our system that participants noted is reduction in face-to-face communication. Participants became so engrossed in sketching and viewing on their individual tablets that they would frequently focus on their Tablet PC in place of looking at each other. However, we note that current whiteboard practice also struggles to support face-to-face communication. Writing at the whiteboard requires turning away from the group and group members orienting towards the whiteboard reduces face-to-face communication between members.

Another limitation of the system is the limited display real estate afforded by the Tablet PCs. Participants mentioned that it was sometimes difficult to manage the space as they often wanted to keep a large number of sketches in view.

Conclusions and Future Work
Results from our pilot study suggest that shared sketching with individual inputs has interesting implications for brainstorming. A larger within subjects experiment is necessary to fully evaluate our system and confirm our observations with statistical significance. In addition, we would like to evaluate the
outcome of the brainstorming task in order to draw conclusions about the benefits our system brings to group brainstorming.

We are also interested in incorporating a private sketching space in addition to the shared public space, a digital analog to logbooks. We believe giving users a space to develop ideas privately and take personal notes while keeping the shared space in view will help address the self-consciousness some participants expressed about sketching their ideas with the current system. Keeping private and public views adjacent would support private sketching without distancing users from the group discussion and would afford the easy transfer of sketches between the two spaces.

We are also interested in utilizing the digital whiteboard to support central focus and expand the number of sketches viewable. Possible exploration could include a way of forcing attention to the digital whiteboard, for example, by momentarily closing the Tablet PC views, or using the digital whiteboard to display multiple pages of sketches or navigate large spaces.

Our pilot study indicates that in a group brainstorming session, a shared sketching space accessed and viewed through networked Tablet PCs and a digital whiteboard even out individual participation within the group because the personal devices lower the threshold for contribution. Unexpectedly, the results indicate a smaller total amount of sketching by the group with our system than in a non-networked condition. Observation of the experiment and interviews with participants raised interesting implications for brainstorming that result from use of a collaborative sketching tool such as greater awareness of individual contribution levels and increased consciousness of the quality of sketches shared with the group.

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References


