On a Side Note - Observations on Using Digital Notes on a Large Display with Users Sitting at Extreme Sides

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Figure 1: Study participants were asked to sit to the left, to the right, or at the center of a large display.

ABSTRACT

Collaborative work on large high-resolution displays is shown to have many advantages and is getting more affordable all the time. Using notes with summaries, ideas, and reminders on large displays can offer improvement on workflows that can benefit from spatial arrangement. In this paper, we focus on the Quick Notes application in the SAGE2 collaborative environment for large displays. Specifically, since visibility of content is diminished at the extreme sides, we want to know what is the connection, if there is one, between sitting position in relation to the large display and workflow.

CCS CONCEPTS

• **Human-centered computing** → *Collaborative and social computing systems and tools*; Visualization systems and tools.

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1 INTRODUCTION

Large displays have increasingly become more affordable and started to take a prominent place in everyday life, from education and commerce to the workplace. Large displays provide greater support for casual or intensive interaction, group work or independent work. Research on utilizing large displays tends to favor scenarios that involve standing and moving in front of the display, or sitting at the center of the display at a comfortable distance [3]. These are ideal views for interaction, where users can immerse themselves within the information on the screen.

However, in our experience, users involved with collaborative group-work often have a different experience. They are likely to stay seated, either to avoid fatigue due to prolonged standing, or to avoid blocking the view from their colleagues, and they may find themselves in disadvantaged seats to the side of the display if

the group is large. In our work, we are interested in exploring the experience of the more disadvantaged users.

Our group-work involves spending a lot of time in front of a large wall-sized display sharing documents and ideas. We support our collaborative work with the open sourced SAGE2 middleware for large displays [12, 14]. With SAGE2, each user connects to the display wall using a web browser. It is a truly collaborative and egalitarian environment, so individuals can use the webUI - a proxy for the wall in their browser - to add, edit, download, and delete any content on the wall. SAGE2 supports synchronization between SAGE2 sites, so remote colleagues can also participate and share. The web based nature of SAGE2 enables easy writing of new tools and applications. One such tool we have been developing and improving recently is the Quick Notes app at the center of this work.

Notes are essential in many use cases. They are the cornerstone of brainstorming sessions, used for summaries of discussion points, and to place reminders for actions that need to be done. On a large display, the abundant space opens possibilities for using notes in a spatially meaningful way.

As a combination of both of these points of interest, in this paper we focus on the questions: What are common strategies for using notes on a large display? Do people sitting at extreme sides use different note strategies than those in the center? Do they have difficulties using notes? In the study we present in this paper, we observed individual users as they perform a structured planning task using a wall sized display wall. We had participants sit at one of three locations (see Figure 1), logged their window manipulations, and asked them about their experience. In the next section, we discuss related work, then we describe our study, our results, and our design recommendations for notes on large displays; both in general and in relation to users sitting at extreme sides.

2 RELATED WORK

SAGE2¹ was a re-implementation of SAGE (Scalable Amplified Group Environment) using only web based technology [12, 14] to allow easy connection, easy application development, and access to existing web content and applications. As an open source middleware for running high resolution tiled displays supporting collaboration, it has been adopted in many locations around the world² and was used for a wide array of scenarios such as sense-making and visualization [13, 15], conference schedule planning [4], and crisis detection [11]. There is a lot of active research around enhancing and introducing novel interactions into SAGE2.

Separate from SAGE2 is ongoing research regarding usage of sticky notes for activities such as design, comparison, and information management [5]. The advantages of paper notes - their tangibility and flexibility, are well known. In a study of paper notes usage for affinity diagramming [7], the authors identified these advantages, but also found participants encountered issues like: physical limitations where notes can fall off or get lost, professional workspaces often don't have the space needed to preserve an increasing amount

of notes over time, and the back-and-forth conversion of information between digital and paper formats to perform the diagramming activity is time consuming and tiresome.

These days there is no shortage of online note applications, but the research community is still interested in understanding, evaluating, and improving how professionals interact with notes. TeleBoard [6] is a web-based collaborative tool intended to simulate the use of sticky notes on a whiteboard. It was evaluated in a company with multiple world locations and showed that participants had positive response to using digital notes in both synchronous and asynchronous collaboration modes. Jensen et al. [8, 9] developed a no-frill digital system that mimics physical notes as closely as possible using mobile devices and compared it to paper notes in a study they conducted. They found that the digital notes were harder to hand-write on a device, distracted the users from the collaboration, and were not as reliable as the paper notes. But the advantages of the digital medium could be observed as long as a balance is maintained between the paper metaphor of the notes and the affordances of the digital format.

For our study, it is worth mentioning that SAGE2's approach to notes leans closer to the digital format, leaving freeform markings to an application called doodle. It is still assumed that most SAGE2 users connect via laptop where mouse and trackpad drawing is inconvenient. As more laptops include touchscreens and more professionals use large tablets for work, this approach may need to be reevaluated. The advantages of using the SAGE2 quick notes system include the seamless integration of notes with other digital documents within SAGE2 and the native support for usage on high resolution tiled displays.

Much of past work showed empirical evidence regarding the advantages of working with large displays in varied context (such as [16], [1], [10]). While comparing large displays to single or dual desktop display setups, Bi et al. [3] reported participants' preference for the large display in most daily tasks. However, their participants sat in an optimal position at the center of the display. Users at the far end of a large display are likely to have a skewed view of the opposite side [2] and the impact of these disadvantageous positions is less explored.

3 METHODOLOGY

3.1 Study Design

The study was designed around a task incorporating usage of digital notes along with other documents. We chose to focus on a planning task, one that is likely to have constraints spread across many documents. We expected participants to lay out the documents across the large display. In addition, since large displays are useful for spatial problem solving, the task involved room assignments for a fictional company.

We divided our space to three sitting positions: the extreme left (group L), center (group C), and extreme right (group R) as seen in Figure 1. At this stage, we limited the study to one user at a time, so we could observe their behavior in the different seats without other confounding factors such as space negotiation.

After collecting consent, the research team ensured that participants had sufficient SAGE2 knowledge to complete the task. To properly complete the task, participants had to be familiar with

¹<http://sage2.sagecommons.org> (Retrieved April 20, 2019)

²<http://sage2.sagecommons.org/community-2/> (Retrieved April 20, 2019)

Figure 2: The interface for the Quick Notes app in SAGE2.

how to use SAGE2 to view pdfs, play videos, open a browser, create notes, and resize/position windows on the display. To that end, participants had to 1- viewed a 6 minute video summarizing SAGE2 usage, 2 - were given a "cheat-sheet" for the basic functionality of SAGE2, and 3 - were asked to complete a practice task. The practice task involved retrieving and reassembling pieces of a picture and required similar skills as the main task.

After the practice task, participants worked on the main task, followed by a survey and an open interview about their strategies and experience. In addition to collecting the survey results and session recordings, a logging application captured the creation/destruction, resizing, and movement of application windows.

3.2 System

The study was performed in our lab on a large flat wall-sized high-resolution tiled display running the SAGE2 collaboration middleware. Participants were asked to use a laptop that was provided and situated for them. The laptop was connected to the wall ahead of time and had a mouse to afford smoother interaction than a trackpad. SAGE2's interface was run from a Chrome browser.

The display wall is comprised of 15 Samsung UD55E-B (1920x1080) displays arranged in a 3x5 grid. The display is controlled via an Intel Xeon CPU E5-2650 v4 @ 2.2GHz (two processors) 64 GB ram, DDR4, 1200MHz, running Windows 10 Enterprise version. As shown in Figure 1, the display is about 20ft. by 6.5ft., and the table for participants' laptop was placed 9 ft. away from the display. This distance was chosen based on the suggestion in [3] that a comfortable viewing distance for a display of a similar size is between 1.5m to 3m. Since many of our participants are already disadvantaged by their seating, we chose a value closer to the higher bound. Participants were not allowed to move the table or the laptop. Figure 3 shows the set-up mid-task.

SAGE2 comes with an application called Quick Note. When launched (see Figure 2) a dialog appears on the webUI where the user can select a color and type text. The text is formatted with markdown³. After a note is created, any user connected to the SAGE2 wall can resize it, move it, or edit it. A note is sticky by default, when placed on top of another application window it will become stuck to it and will move along with that window. While stuck, an icon appears on the note's title bar indicating it is attached. Clicking on that icon detaches the note to a freestanding mode.

3.3 Participants

In total, we recruited 15 participants (F=5) with an average age of 27.3 (sd=5.6). All participants were right handed. The participants

³<https://daringfireball.net/projects/markdown/> (Retrieved April 20, 2019)

Figure 3: A participant in front of the display wall.

were intensive technology users with 50% reporting 8+ hours of use each day. More than half (9/15) use multiple displays in their home or work computer setup. Each participant was randomly assigned to group L, C, or R.

We recruited participants from our lab, or affiliated with our lab, since we wanted participants with some SAGE2 experience. According to their own estimation of familiarity with SAGE2, among group L, four participants had medium to low familiarity, and one was a regular user, among group C, three had low familiarity and two were regular users, among group R, two participants had low familiarity, two had medium familiarity, and one had high (daily) familiarity. All participants had enough SAGE2 experience to feel comfortable while they completed the task.

3.4 Task Description

Each session required two researchers and a participant. One researcher introduced a document with the task description and started the logging application. The first instruction prompted participants to open a video chat window to the second researcher who was representing a remote collaborator. The collaborator was introduced to this scenario to mimic a real world situation, and to allow control over the flow of information to the participant. The task description included a list of documents the participant can ask their collaborator to share over SAGE2. These documents had the information needed to assign employees of a fictitious company to new offices. Among the documents: a floor plan, an organizational chart with the names of the employees in the company arranged by departments, and a collection of other documents (emails or memos) with assignment restrictions. Participants were instructed to perform their work on the display wall and arrange their thoughts using SAGE2 notes.

4 RESULTS

Based on our recorded footage, it took an average of 47 minutes to complete the main task. Figure 4 shows a recreation of the last layout on the display for all participants with the notes highlighted in green.

All participants completed the task. We did not measure the accuracy of their room assignments, as the cognitive element of the task was not focal to our study. According to the survey (Figure 5), participants had a positive experience using SAGE2 on the large display, with only one participant disliking the abundant space. Participants differed about whether they would have preferred completing the task on a laptop. Some stated in their interview that they wouldn't even know how to do the task on a laptop considering the amount of information involved.

Figure 4: Study final arrangement by window types, blue for the floor-plan image, green for the notes.

Figure 5: Survey results, depicting how participants felt SAGE2 accommodated their work on the task.

We observed three main note usage strategies (See Figure 6 for examples). The main, anticipated strategy involved creating separate notes for the individuals that needed a room assignment and spatially arranging them on the floor-plan according to the requirements - eight participants used this approach.

"I was trying to get a better visual picture of whatever I was trying to do... I'm a more visual person so I needed to see the note in the layout, and so I decided to switch to individual names." (C5)

A second strategy, often used with conjunction to the first strategy, involved creating a "big" note to keep track of requirements as the information pours in - seven participants used this approach.

"I quickly realized that the task was going to be more than I can hold in my head, so I decided to open up the note, the notes that have markdown, I like mark-down..." (L4)

"So that way it was just easier for me to put all of my important information in one note, and then my organization in another." (R3)

Figure 6: Strategies: a. Individual notes arranged spatially on top of the floor-plan. b. Large note containing a long list. c. Medium sized notes used to group together related items.

Curiously, three participants did not want to work with notes on the large display, and found a workaround. They created one big note, and used the note's editing mode to see the content as if it were a text file on the laptop.

"I didn't like making sticky notes, or moving them around or editing them.... The post-its were fussy for me, even with one." (R2)

"...I mean the notes was on the laptop so I can't really say anything about that." (L3)

"So the notes, you can't see them up there... but for me it's only on the laptop." (R3)

The third strategy involved creating medium or small notes to hold requirements or multiple assignments. These notes were sometimes arranged spatially according to "assignments in progress" and "completed assignments", or participants used them to visually separate information about different departments.

"I liked that I was able to use the notes to kind of group different teams together." (C3)

"I think I tried to keep all the post-its together near the top, and then when I was pretty sure where the office assignments, then I would put it on the bottom to separate them." (L2)

We were interested to see how participants used the note colors. Based on one of the documents given to the participants, the task offered a natural color mapping between departments and note colors orange, blue, and green. Some participants utilized this mapping, others found different color schemes, for example, using colors to differentiate work in progress and completed work. Four participants did not use any colors other than the default yellow, but one of them (R5) admitted that they had considered color coding, but though it would be too much work.

"Once I came up with the idea to color code by team, and then have the current running office assignments on the note for that team, I kind of just ran with that." (C3)

Table 1: Features of Note Usage

	# notes	spatial	color	format
L1	22	•	•	•
L2	22	•	•	•
L3	1			
L4	16	•	•	•
L5	13	•	•	
C1	24	•	•	•
C2	18	•	•	
C3	7		•	•
C4	3			
C5	20	•	•	•
R1	17	•	•	
R2	2			•
R3	2		•	
R4	5		•	
R5	20	•		

"The main lady is blue, the executives yellow, the designers are red and everything else is green." (L5)

Table 1 summarizes the number of notes for each participant and whether they used spatial organization of any kind, a color scheme, and the notes' formatting abilities (markdown or adding arrows). Only three participants used formatting purposefully. For other participants, markdown appeared accidentally and they did not necessarily notice it. For two participants, the automatically applied markdown conflicted with their desired note appearance.

The effect of sitting position is not clearly evident from our data. The three strategies we described were used by all groups. The strategies produced a different number of notes, so we cannot draw numerical trends from the data extracted from the logging application. We therefore describe trends from the overall position of windows throughout the task (using heatmaps like Figure 7), observed behavior during the sessions, and participants' interview comments.

First, we should note that participants in group R (the extreme right) expressed their discomfort with the sitting position more emotionally than participants in group L. Most participants in group L and R, even before they were asked, expressed the discomfort of turning their heads to the far side. Most were also sure they would use the space differently if they were to sit in the center. Notable, those in group R consistently used stronger language regarding their seating position. According to their reflections, the sitting position had a strong impact on their work.

"Text in particular, notes or emails, I could not read when they were on the left side of the screen, I felt, unless I decided to blow them up to half the screen size" (R1)

Figure 7: Heatmaps for notes over time per participant.

"That was my garbage side I can't see anything (gestures to left)." (R2)

"I put garbage on the left side and put stuff I wanted to read on the right side." (R4)

However, we can see from the charts in Figure 7 that even group R, with the exception of R2, had notes placed on the left side of the screen at some part of the session. Group C, which sat to the center of the screen also used the left side heavily. In addition, while some participants flushed notes with the bottom of the screen, some place windows vertically closer to the top. This surprised us, as the top is cluttered with SAGE2 related information bars.

5 DISCUSSION AND RECOMMENDATIONS

Participants worked differently to solve the task. Factors other than their sitting position are evident. However, there are some interesting points to note. We speculate that the trend to position notes on the left is influenced by the participants' reading direction (in English, from left to right), but SAGE2 also has a hand in this. When a note is created, it is by default created on the top-left side of the screen and subsequent notes will be created to the right of that position. There is room to investigate the effect of initial window placement on large displays. The wide spread of notes we see by participants - other than the three who chose to view their note locally on the laptop - tells us that most users did not have difficulty reading short and medium notes spread across the large display. This is likely due to the large default font size SAGE2 uses. The font size of a note can be made bigger or smaller, however, none of the participants chose to use that, indicating that the default size value is sufficient.

Other interesting comments we gathered from participants involved features of SAGE2 itself. A few mentioned they would have liked to doodle or add names directly on the floor-plan and not via note. There is a tool for that in SAGE2, however, it is not comfortable to use with a mouse, so it is not commonly used. Another feature of the notes that surprised some of our participants is their stickiness. When a note is placed on another document it will move when the document under it is moved. This is based on the common

metaphor of sticky notes, but still confused some of our participants. They figured it out by themselves, but this demonstrates the inefficacy of the current "sticky" feedback icon.

"I didn't expect it, I expected just to click on that one and then being able to move it, so I guess it was a little.. confusing, but once I figured out that: oh, the one on the bottom is why it's stuck, so if I move the one on the top over, then I can move this." (C5)

The regular SAGE2 users were already familiar with the note stickiness and used it to their advantage, by, for example, stacking notes together so they can move them in one drag across the screen, or dragging the floor-plan itself, knowing that the notes on it will move with it.

5.1 Design Recommendations

Based on this study we offer some design recommendations for notes on large displays, both general and relating to sitting position.

5.1.1 Strong Default - Size and Location. The goal of default settings is to provide a good starting point that will fit most cases. On a large display, we need to weigh the possible needs of users sitting at extreme sides and use them as a basis for our default values. Fonts should be bigger than they would for users in optimal seats. Notes should initially show up close to the user, or the user should have a way of initially placing the note themselves (some systems implement this by having a separate note object that needs to be dragged to the screen area.)

5.1.2 Easy Change - Color and Formatting. Note coloring is a powerful mechanism for organized work, and formatting enhances note versatility. It should not be a hassle to change a note's color, and formatting should assist, not limit users. Therefore, the interface to change the color of an existing note should be clearly visible, and not, as it is often, hidden behind other UI components. Whether or nor formatting is used (especially markdown) should be specified by the user as a preference.

5.1.3 Movability and Resizability. Large displays notoriously suffer from uncomfortable long distance dragging for moving or resizing windows. SAGE2 eases this problem with a proxy of the large display on a smaller device. Still, users don't move notes unless they are motivated to do so by their selected strategy. In addition, since we normally associate notes with short text snippets, we were surprised to see that some of the notes were very long. Other than the built-in moving and resizing abilities, users can benefit from automated, context related, moving and resizing, for example, as a note becomes lengthier, the system may automatically place it higher on the screen and increase its window size.

5.1.4 Clear Feedback. It is part of every good design to have clear feedback for the state of an application, such as being sticky, but *what* makes feedback clear is harder to pinpoint. In our example, the "sticky" icon on the title bar was clear for regular users and unnoticeable for less experienced users, so the later could not incorporate stickiness in their workflow. Despite the temptation to keep digital notes visually minimal like paper notes, digital notes have state complexity that needs feedback, especially if they can be sticky but not attached, sticky and attached, and not sticky at

all. Designers should include strong visual and auditory cues to indicate the state of a note.

5.1.5 Aggregation and Modularity. Notes proved to be lengthier than we anticipated. Some participants used them as check lists, editing notes to remove entries they didn't want anymore. Some participants had notes that they grouped physically in some location to indicate that they are conceptually related. We suggest to devise better tools to support seamless note aggregation and modularity. These tools can afford better workflows by allowing the user to easily cluster several notes together, or break lengthy notes to smaller re-arrangeable components.

5.2 Limitations

Our study suffers from several limitations. The number of participants was small, placing five participants per group. Having single-user sessions was a design choice meant to simplify the data inspection, however, in the future, group-work studies will provide richer results. Also, to replicate the working environment our group is familiar with, using SAGE2, the participants controlled the wall using indirect input on a laptop while seated. We avoided direct touch interaction on the wall since the majority of the walls we work with are too large to reach with touch and only three among about 100 have touch capability. We realize that this work environment may not generalize to other systems, however, we believe that our recommendations are general, and that this paper provides a gateway to more position-based studies.

6 CONCLUSION AND FUTURE WORK

In this work, we examined how users interact with SAGE2's quick notes system on a large wall-sized display in a structured planning task. We distributed participants' sitting positions to three positions: extreme left, center, and extreme right. We saw that participants used a different number of notes, from one big note for all of their thoughts, several medium notes meant to separate bits of information in meaningful ways, and making individual notes for each item and using the spatial affordance of the display.

The participants sitting to the far right were far more inconvenienced than participants sitting to the far left. We suggest it is caused by a combination of left-to-right reading convention and the default location of new Notes. Despite the inconvenience, almost all participants had notes on the left side of the screen at least some of the time. Some participants placed notes with short text on the opposite side of their sitting location and stated they had no difficulty reading them due to the acceptably large text. Participants had feedback about other aspects of our quick notes system, and the previous section describes our design recommendations, which we intend to incorporate in future releases of SAGE2.

Our specific task was open enough to allow different strategies with different numbers of notes, however, the single-user format is limited, therefore, the next natural step in our investigation of this space will include groups of users.

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