# User Study of a Large-scale, Multi-touch Display (*Lasso*): User Interaction and Collaboration in Single- and Multi-touch Enabled Applications on *Lasso*

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**ABSTRACT**

Now, more and more electronic devices employ touch interfaces, enabling users to interact with a device by physically touching the screen. Positive user experience with touch screens has led to the permeation of touch-based systems in daily life, making touch displays ubiquitous in casual use. Perhaps a natural step in technological advancement is the production of large touch displays, and in recent years, research and development has been focused on large, high-resolution touch displays, such as tabletop and wall displays. These large interactive displays have made their way into public or semi-public spaces, such as meeting rooms and information desks, to encourage knowledge sharing and collaboration, but while the technical development for these displays is plentiful, evaluative research on the use, usability, and user experience of them is not. In this research, then, we investigate the usability and user experience of a large-scale, multi-touch display (Lasso) by exploring how users interact with the display and each other during collaborative tasks. Specifically, we explored the following questions regarding touch interaction, collaboration, and touch application use on a large-scale, multi-touch display (Lasso): 1) How do users interact with a vertical large-scale, multi-touch display; 2) How do users interact with single- and multi-touch enabled applications on Lasso in a collaborative setting; 3) How do users behave when interacting with Lasso in a collaborative setting; and 4) How can touch interaction with Lasso facilitate collaboration over the use of traditional input devices?

**Keywords**

Large shared display, touch interaction, single user application, multi-touch application, collaboration



**INTRODUCTION**

Surface-based touch interactions are currently employed in multiple devices, mobile, desktop, laptop, kiosks, and others, enabling direct manipulation of digital objects via gestures involving hand or finger movement (Saffer, 2008). As the multi-touch interface is a relatively new, but increasingly common method for user interaction, an increasing amount of research is exploring user behavior on expanded touch screens and feasible touch applications. Accordingly, there has been a growing interest in contextual use, ranging from indoor to outdoor environments and from personal space to workplace (Benko, Wilson, & Baudish, 2008).

Huang et al. point out, however, that because large interactive displays are often supplemental technologies and not primary tools for work activities, they face difficulties in real-world deployments. In order to integrate a large interactive display into a real-world work environment, they explain that users must perceive the system as valuable, easy to use, and available when they need it (Huang, 2007). In the present study, we test the value and ease-of-use of a specific large multi-touch display, Lasso, at The University of Texas at Austin.

As with various other large touch displays, Lasso is conducive to collaborative activities rather than tasks requiring accurate and efficient input devices (Russell, 2002). When multiple users take part in group activities, the affordance associated with collaboration on shared displays encourages decision-making, mutual engagement, access control, etc. (Jordà et al, 2010). Shared displays afford knowledge sharing in collaborative environments and in some research, is shown to be preferred over pen-and-paper (Streng, 2010). In this research, we explore how multiple users collaborate on one single, large display and whether touch interaction encourages cooperative decision-making, engagement, and control.

## RELATED WORK

Lasso is a fully-operated touch interface in a workstation running Windows 7 and Linux, and direct interaction with the display replaces the use of traditional input devices such as a keyboard and a mouse (Saffer, 2008). Installed Window applications can be operated with single touch interaction by recognizing only one click at a time. The touch interaction by a single point means that users can use touch as an input device similar to using a Mouse. It is possible for users to naturally manipulate applications that function in WIMP (Windows, Icons, Menus, and Pointing device) interfaces, based on similar usage models. However, single touch applications are not satisfying in collaborative situations, when multiple, co-located people perform a cooperative task together. Traditional software with a single input does not afford asynchronous mode in input and control situations (Xu et al., 2006).

The multi-touch applications were originally developed to recognize multiple points predefined at the system level, allowing users to make contact with the interface simultaneously at multiple points in order to leverage collaborative activity. However, on large displays, it might be difficult to see and understand a person's interactions during group collaboration (Tse et al., 2006). Wallace et al. (2008) investigated single display groupware and found that it provides more awareness of each collaborator's activities in cooperative task performance. The single display groupware showed less coordination problems over multiple displays. Multi-touch interactions that depend on application development may pose significant challenges for multiple users to control digital objects with fingers or hands on large display surfaces. Thus, we investigated user interaction and collaboration through two different types of touch applications: single- and multiple-touch.

In addition to multi-touch capabilities, Lasso affords knowledge sharing and collaboration on a large display. It is situated vertically and is four feet long by 10 feet wide. Because "physical display size, independent of other factors, elicits cognitive and behavioral responses that can affect task performance on spatial tasks" (Tan 2004, 2006), we observed the effect of Lasso's physical size on collaboration.

### Collocated Interaction on Large Multi-touch Displays

Large display systems serve a range of purposes in situated settings or public environments. Peltonen et al. (2008) categorized public interactive displays based on social interactions and position orientations such as ambient, tabletop, and wall displays. Ambient displays are used to call attention to a peripheral exhibition rather than direct manipulation on a display's surface. Wall displays are vertically-oriented to support walk up and use by multiple users, while the tabletop display is a type that allows users to interact with the table surface while standing or sitting around it. Rogers and Lindley (2004) found that the orientation of large interactive displays affected collaboration; horizontal group members switched roles more often, explored more ideas, and were more aware of what other members of the group were doing, while vertical group members had a difficult time collaborating.

Many single large displays are used for multiple users to simultaneously interact with shared applications (Izadi et al., 2003). Studies on multiple users interacting with shared displays cover concerns related to collaborative use in specified areas, such as an educational space or a workplace environment. In a collaborative environment, a touch-based system, which falls under the category of gesture interfaces, can serve to convey a user's intentions to other users. Gesture can play a role in facilitating thinking and learning as well as for communication purposes when collaborating with others (Hoven & Mazalek, 2011). Morris et al. (2006) introduced cooperative gestures that allow multiple users to interact with a shared display system. They identified features and motivations regarding cooperative gesturing on a multi-user display. Their research shows that gesture interaction can invoke awareness of vital program actions while users collaborate. They also observed issues regarding personal territory, target objects, and social interaction. These challenges require restricting types of access such as editing or deleting, when materials are shared on a single display.

Wallace et al. (2008) investigated teamwork and taskwork of collaboration in single- and multi- display groupware systems. While the taskwork measures can be used to indicate the effectiveness and productivity of a system, the teamwork measured three aspects of collaboration: communication, awareness, and coordination. These three aspects provide an essential lens to view activities that take place in group collaboration (Pinelle, Gutwin, and Greenberg (2003) and Sharp, Rogers, and Preece (2007)). The results exhibited that single-display groupware provides more awareness of the collaborators' activities in cooperative task performance. The single-display groupware showed less coordination problems over multi-displays.

Yuill and Rogers (2012) identify three mechanisms that make multi-user interfaces "successful" and "provide natural interaction" for collaboration: awareness of others' actions and intentions, control over the interface, and availability of background information, or "the ways in which background information relevant to users' behavior and to the task is made available or externalized." Natural and successful collaboration is, according to Chen et al. (2011), "the core problem to solve" to promote information sharing and collaboration on large, multi-touch displays in a public space.

The collaborative use of large touchscreen has also been explored in educational settings. Fleck et al. (2009) presented OurSpace, a collaborative application designed to allow groups of young school children to plan their classroom layout using a multi-touch tabletop interface. They identified verbal and physical interactions associated with learning and using the touchscreen. They suggested that actions that seemed harmful, such as grabbing an object from another user or undoing another's actions, might actually be beneficial for collaborative learning because they trigger further discussion among the group. This facilitation of social interaction can be seen in the workplace as well, where not all large interactive displays are used for explicit work purposes. Pajo et al. (2009) designed a large interactive display, for example, to facilitate social interaction among co-workers.

A large amount of research in this field uncovers various issues, encompassing the moments when multiple users interact with interactive touch-interfaces. However, more studies regarding large-sized multi-touch screens must be conducted as large-sized, multi-touch displays are still an unusual area for ubiquitous placement toward casual use.

## TEST SYSTEMS

### *Lasso* Display

*Lasso*, the large, multi-touch display used in this study, is approximately ten feet wide by four feet high, and is situated upright a few feet off the ground, similar in size and orientation to a blackboard in a classroom, pictured in Figure 1. The tiled screen is recognized as a single display surface. The display is multi-touch enabled, supporting up to 32 simultaneous touch detection points. It allows users to control applications with fingers as well as with traditional input devices, such as a mouse or keyboard.

The configuration of the computer running the multi-touch display includes 2 Intel Xeon 5355 quad-core processors, 16 GB of RAM, a 1.5 TB local disk, and an nVidia Quadro FX4600 Graphics Card with 1.5GB memory. It is located in the Visualization Lab of the Texas Advanced Computing Center (TACC).


**Figure 1. *Lasso* display**

### Single- and Multi-touch Applications

For the test, two applications, Sankoré and pyFlowChart, were selected to focus on group activities which can occur in a classroom space (see Table 1). Sankoré is a stand-alone whiteboard application, which is a open-source teaching software compatible with every type of digital interactive device. Sankoré is not technically specified for multi-touch interaction and thus functions by recognizing only one point at a time. pyFlowChart is a flowchart drawing application developed by pyMT module, which is an open source library for developing multi-touch applications.

| Applications | Touch Interaction | Interface |
|---|---|---|
| Sankoré | Single Touch | WIMP/GUI |
| pyFlowChart | Multiple Touch | No menus |

**Table 1. Touch applications**

## THE USER TEST

To explore the use of the large-scale, multi-touch screen (*Lasso*), a user test was executed in groups—consisting of three participants each—performed two collaborative tasks together. The user test involved both qualitative and quantitative research methods. The qualitative methods utilize data obtained from observation, task performance, and user interviews. The quantitative methods include the data analysis of four kinds of questionnaires: a demographic survey, two application usage questionnaires, and a post-test questionnaire.

The demographic survey provided data regarding demographic information, experience with computers and touch applications, and use of documentation software. Two application usage questionnaires included the same questions regarding the specific application used in each collaborative task. They included questions regarding test participants' judgment of each application's ease of use, ease of learning, satisfaction, enjoyment, and preference. Collaboration questions involved comfort level, preference, perceptions of group communication, interaction conflict, and awareness in group collaboration when using the given application. The questionnaires used a five-point Likert scale to measure the extent to which a user agreed or disagreed with the question, from "strongly disagree" to "strongly agree." Conflict and awareness questions were posed with a five-point Likert scale as well, from "not at all" to "a great deal."

The post-test questionnaire evaluated users' judgments about the usability of and user experience with *Lasso* display. Questions regarded ease of use, ease of learning, effectiveness, ease of browsing, satisfaction, frustration, stress, enjoyment, practicality, intention to recommend, and use intention. In addition, participants provided feedback on their preference of each touch interaction (single- or multi-input) and applications (Sankoré or pyFlowChart).

### Participants

Since the two applications used in the test could be used as educational tools, we examined cooperative activities in a learning environment. Thus, we targeted students at the university level. We recruited participants among undergraduate and graduate students and university staff who could read and speak in English at a university level at the University of Texas at Austin. The total sample size was 24 students and staff. There were a total of eight groups, with three participants each.

### The Input Setting

We used two different input conditions during the user test in order to gauge user behavior and touch interaction according to the use of input options. In condition A, participants used only direct touch interaction for completing a task. Any other input devices like a mouse or keyboard were not provided to participants in this condition. Condition B allowed participants to use both hand-based touch manipulation and shared input devices, including a keyboard and a mouse (see Table 2).

| Conditions | A | B |
|---|---|---|
| Input settings | Only hand-based touch manipulation | Both of hand-based touch manipulation and shared input devices |

**Table 2. Input settings**

### Tasks

A set of two tasks were designed to investigate user behavior when conducting collaborative tasks in each of two input settings (see Table 2). In Task 1, participants were instructed to sketch layouts for Web pages of a newspaper using Sankoré. In Task 2, participants were designed to create a flow chart for a process of sharing a news story from www.nytimes.com into social media using pyFlowChart. Refer to Appendix E for the task scenario.

### Procedure

The user test consisted of seven parts: 1) introduction 2) pre-test questionnaire, 3) task session 1, 4) break time, 5) task session 2, 6) post-test questionnaire, and 7) exit Interview. Before beginning the task session, the participants were informed of this research, confirming anonymity. Any questions which participants might have were answered at this point. They proceeded to a short pre-test questionnaire to collect data regarding demographic information and experience with computers, touchscreens, and the software applications that were tested.

In each task session, participants were asked to complete the two tasks using *Lasso*. There was no training or warm-up period before the tasks. Participants had 15 minutes to complete each task. They performed tasks by freely interacting with the display or communicating with group members. During the task sessions, the researchers took observational notes. After each task test session, the participants were asked to answer an application usage questionnaire. After completing the second task, they completed a post-test questionnaire. Finally, each test group proceeded to a semi-structured interview together. Please refer to Appendix D for the user interview feedback.

In the task sessions, groups performed an assigned task in a different input condition. The presentation order of input conditions and tasks were systematically controlled through a 4x2 randomized block designs with two replications (see Table 3) to prevent learning bias. For instance, group 1 completed task 1 in input condition A in the first task session, followed by performing task 2 in input condition B. Group 2 was assigned to conduct task 2 in input condition A, then task 1 in input condition B.

All data obtained from this research was collected anonymously. In the user test, user numbers following the order of participants scheduled were only used as the identification number to identify and analyze the data.

| Groups | Session 1 | Session 2 |
|---|---|---|
| 1 | Only touch, task 1 | All input, task 2 |
| 2 | Only touch, task 2 | All input, task 1 |
| 3 | All input, task 1 | Only touch, task 2 |
| 4 | All input, task 2 | Only touch, task 1 |
| 5 | Only touch, task 1 | All input, task 2 |
| 6 | Only touch, task 2 | All input, task 1 |
| 7 | All input, task 1 | Only touch, task 2 |
| 8 | All input, task 2 | Only touch, task 1 |

**Table 3. The input conditions and tasks presentation order**

## RESULTS

From the user tests, the data regarding each questionnaire (demographic survey, two application usage questionnaire, and post-test questionnaire), completed tasks, observation, and interview were collected. The data from the questionnaires were used for statistical analysis, including frequency, correlation, paired t-test, and independent t-test methods. Completed tasks were evaluated for the degree of completion in two applications and input conditions. The observation notes and interview feedback were analyzed for users' behavior and experience during task sessions.

### Demographics Statistics

The participants consisted of 17 females and 7 males. The average age was 29 with an age from 18 to 41. They were all very familiar with computers, with an average 18 years of computer experience. Twenty-one users (87%) had experienced with personal touch devices and touch applications. The majority had a smartphone, a tablet, or both type of devices. They indicated that they all have proficient skills on documentation software.

### Task Completion

Because each task was fairly complex and had to be completed in a short period of time (15 minutes), we used comparative criteria to evaluate each completed task. A total of 16 tasks were completed by the eight test groups, and the whiteboard or flowchart produced at the end of each task was evaluated in three degrees of performance: poor, fair, or good. Three researchers of this study evaluated each group's performance using the whiteboard and flowchart and overall performance on both tasks together.

Figure 2 shows that participants performed better on whiteboard than on flowchart in the level of good performance. Most flowchart tasks were completed at the fair level. Participants completed tasks well when using multiple inputs, including a shared keyboard and mouse, while tasks using only direct touch showed an equivalent level in performance.

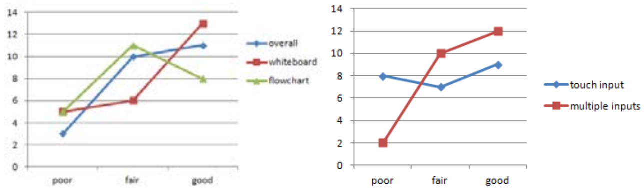


**Figure 2. Task completion of eight groups**

**Whiteboard vs. Flowchart Applications**

The data obtained from the questionnaire on whiteboard and flowchart usage were used to compare users' perceptions of functionality and the interface between the two applications. The difference between the whiteboard and flowchart were compared (see Table 4). The means of four variables ("easy to learn," "satisfaction," "like," and "preference over traditional whiteboard") in the whiteboard application were ranked higher than those in flowchart application. The other two variables' means ("easy to use" and "time on task") did not show a significant difference between two applications.

A paired t-test was performed to assess whether the values of variables in the whiteboard were significantly different from those of variables in the flowchart. The difference of "easy to learn" and "preference over traditional tool" variables between whiteboard and flowchart was highly significant (p=.028 and p=.047). This suggests that the whiteboard application was easier to learn than the flowchart application, and the participants preferred the electronic whiteboard to the flowchart application.

| Application use | Whiteboard | | Flowchart | | Paired t-test | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | t | Sig. |
| Easy to use | 2.54 | 1.02 | 2.58 | 1.18 | -.140 | .890 |
| Easy to learn | 3.17 | .96 | 2.46 | 1.10 | 2.378 | .026(**) |
| Time on task | 3.08 | 1.50 | 3.71 | 1.27 | -1.502 | .147 |
| Satisfaction | 2.83 | 1.24 | 2.38 | 1.06 | 1.494 | .149 |
| Likeness | 2.83 | 1.09 | 2.75 | 1.29 | .257 | .799 |
| Preference | 2.79 | 1.32 | 2.38 | 1.38 | 2.095 | .047(**) |

** is significant at the 0.05 level

**Table 4. Comparison of two application use in the paired t-test**

After using the two applications, the participants were asked to choose which application and touch interaction they preferred for collaborative work. The whiteboard ranked well for two types of interaction(see Figure 2). Eighteen participants (62%) selected the whiteboard for both touch interaction and application for collaboration. This suggests that users preferred the whiteboard, even if there were no significant differences of efficiency between the two applications in collaborative work.

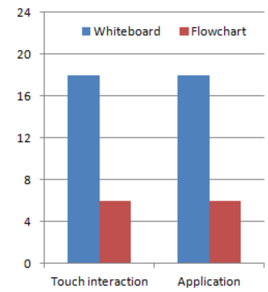


**Figure 3. Preference of touch interaction and application**

*Interface Features Perceived*

While the participants performed their tasks in each application, the researchers observed participants' interactions with the large touch display. We noticed positive and negative features of whiteboard usage. Although the whiteboard application has a familiar menu, most participants did not notice it quickly, as it is located to the far-right of the large display. The menu distance from the center of the display and the small size of menu icons discouraged use during the task. When writing and drawing, then, most groups used their fingers like a marker pen, instead of selecting menu tools.

On the other hand, since the flowchart did not have a menu interface, all groups spent more time figuring out the application's functions. The participants expressed pleasure and positive emotions when they used the interactive functions of the flowchart, such as zooming in and out, rotating, and dragging objects.

**Touch Input vs Multiple Inputs**

We investigated collaborative work by using each application in relation to two input conditions: only hand-based touch manipulation and the use of both hand-based touch manipulation and shared input devices (mouse and keyboard). We used independent t-tests to compare two input conditions in each application. In collaborative work on the whiteboard application, there is no significant difference between the two input conditions. The means of all variables between the two input settings did not show significant difference in the whiteboard application.

| Whiteboard | Touch input | | Multiple inputs | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Easy to use | 2.67 | 1.16 | 2.42 | .90 |
| Easy to learn | 3.25 | 1.14 | 3.08 | .79 |
| Time on task | 2.75 | 1.60 | 3.42 | 1.38 |
| Satisfaction | 2.58 | 1.31 | 3.08 | 1.17 |

| | | | | |
|---|---|---|---|---|
| Likeness | 2.83 | 1.34 | 2.83 | .84 |
| Preference | 2.67 | 1.67 | 2.92 | .90 |

**Table 5. Means of two input conditions in whiteboard use**

The flowchart application presents significant difference between direct touch and all input use in three variables: "easy to use," "time on task," and "satisfaction." The means of three variables in all input use are ranked higher than those in the case of using only single touch (see Table 6). These variables are conceptually related to efficiency aspects to perform tasks. This suggests that the participants preferred the use of a traditional keyboard and mouse along with hand-based touch interaction when performing tasks on a large display, even though the flowchart was a multi-touch oriented and enabled application.

| Flowchart | Touch input | | Multiple inputs | | t-test | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | t | Sig. |
| Easy to use | 2.08 | 1.24 | 3.08 | .90 | -2.260 | .034 (**) |
| Easy to learn | 2.33 | 1.16 | 2.58 | 1.08 | -.547 | .590 |
| Time on task | 3.00 | 1.35 | 4.42 | .67 | -3.261 | .004 (**) |
| Satisfaction | 1.92 | .90 | 2.83 | 1.03 | -2.321 | .030 (**) |
| Likeness | 2.50 | 1.31 | 3.00 | 1.28 | -.944 | .355 |
| Preference | 2.00 | 1.04 | 2.75 | 1.60 | -1.358 | .188 |

**Table 6. Means of two input conditions in flowchart use**

After the participants used each of the input types in the assigned applications during cooperative tasks, they were also asked to choose which input type they preferred in terms of four items: comfort level, effectiveness, ease of typing, and preference for collaborative work conditions. The result show that they liked and preferred the use of both touch interaction and traditional input devices rather than only a single-touch interaction.

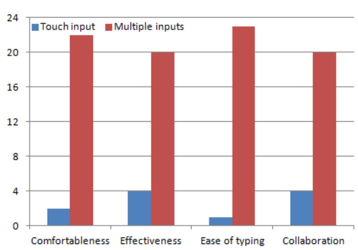


**Figure 4. Preference of input types**

*Behavior in multiple inputs*

The addition of multiple inputs had varied success based on the participants themselves. When there was not clear dialogue between the participants, the multiple inputs generated confusion and some hostility.

However, when individuals took on a specific role such as the "touch person" or the "keyboard person" when using multiple forms of input, the results were different. Some groups were able to use this to efficiently organize group work, with each member acting out a role to help the team accomplish a common goal.

Thus, the two forms of input—when harnessed differently—gave rise to two different forms of collaboration. When a group cooperatively collaborated, for example, the group liked multiple inputs. Conversely, when group members were frustrated and not working cooperatively, the multiple inputs gave rise to confusion.

**Collaboration**

After performing the assigned tasks for each application, the participants completed a final questionnaire, which focused on collaboration. The data obtained from the questionnaires were used to analyze affective perception, communication, coordination, and awareness aspects in collaborative tasks. With regard to affective perception, we evaluated comfortableness and likeness in performing collaborative tasks. Three questions regarding communication involve if they had enough, comprehensive, and effective communication with group members. To analyze coordination in cooperative work, we asked if the participants have interaction conflicts between members. They answered two questions of awareness if they were aware of others' action and own action during the test.

The result shows that the means of all variables in collaboration are scored over the average (3 out of 5) except the interaction conflict (see Table 7). This means that they performed cooperative works with less interaction conflicts. The difference of all variables of collaboration between whiteboard and flowchart was not significant at the 0.05 level from the result of the paired t-test. This suggests that the collaboration can be assumed with other aspects rather than two types of application.

| Collaboration | Whiteboard | | Flowchart | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Comfortableness | 3.67 | .96 | 3.46 | 1.06 |
| Likeness | 3.71 | 1.0 | 3.54 | 1.22 |
| Enough communication | 4.13 | .90 | 4.13 | .85 |
| Interpreted communication | 4.13 | .85 | 4.13 | .80 |
| Effective communication | 4.25 | .79 | 4.08 | .83 |
| Interaction conflicts | 2.25 | 1.23 | 2.38 | 1.47 |
| Awareness | 4.08 | .93 | 4.08 | .88 |
| Other's Awareness | 3.92 | .83 | 4.17 | .82 |

**Table 7. Means of collaboration variables in the paired t-test**

### *Cooperative Behavior*

Most participants verbally shared what functions they found and what activities they were doing during the test. When they had interaction conflict, they talked each other like 'Hold on, I will click'. In addition, when group members had difficulty with touch interaction or made mistakes, they ended up helping their group members use the application. These cases caused a great deal of communication between group members.

## Touch Interaction with *Lasso*

Since the large multi-touch display (*Lasso*) was used for the purpose of performing collaborative works, we investigated participants' interaction and experience with the display. After two task sessions, the participants answered 11 questions regarding the experience of the *Lasso* display. Four out of 11 variables were scored above average: "easy to learn," "frustration," "enjoyment," and "use intention in the future" (see Table 8).

The correlation analysis was used to explore whether there are associations between the 11 variables in the experience of the *Lasso* display. Refer to the Appendix for the result of correlation analysis. The results of the correlation analysis showed that all variables have positive correlation except the "stress" variable. The variable "easy to use" was correlated with 6 other variables: "easy to learn," "effectiveness," "satisfaction," "enjoyment," "practical to use," and "use intention in the future." Stress using the display was negatively correlated with "easy to learn," "effectiveness," "satisfaction," and "use intention in the future." The "practical to use" variable was significantly correlated with 5 variables: "easy to use," "easy to learn," "satisfaction," "enjoyment," and "use intention in the future."

| Variables | Mean | SD |
|---|---|---|
| Easy to use | 2.83 | .963 |
| Easy to learn | 3.25 | .737 |
| Effectiveness | 2.75 | 1.152 |
| Easy to browse | 2.75 | .989 |
| Satisfaction | 2.67 | 1.049 |
| Frustration | 3.54 | 1.062 |
| Stress | 2.79 | 1.215 |
| Enjoyment | 3.46 | 1.103 |
| Practical to use | 2.58 | 1.176 |
| Intention to recommend | 2.67 | 1.239 |
| Use intention | 3.38 | 1.245 |

**Table 8. Experience of *Lasso* touch screen**

### *Group Interaction*

When observing the groups of test participants, there seemed to emerge two basic types of interaction. There were those who treated the interaction with the display as a play act, and those who approached the tasks given as work. This interaction style gave rise to different levels of user success in accomplishing the given tasks. Those who "played" tended to be more communicative with each other and seemed to learn as they went, while the "work" groups tended to become more frustrated, and less communicative, repeating failed interactions during the tasks.

### *Movement*

The level of personal space played a large role in the manner in which participants interacted not only with the screen, but with each other. Those willing to enter each others' space tended to interact more fully with the display and each other. This tended to make for a more collaborative effort when using touch control only.

## Interview Analysis

During the exit interview, many participants had similar responses to questions regarding Lasso. When asked about using the display, the size was a plus in terms of navigating the field, or moving around each other. However, the screen was large enough that one could lose sight of an object on the other side of the screen, such as the menu in the whiteboard application.

All participants mentioned that they expected the touch display to be easier to use, although it is difficult to distinguish whether the display itself or the applications lacked usability. Some participants wanted instructions to be included on the display, and many participants wanted the touch interaction to be more accurate and responsive to errors. It was difficult, for example, for participants to undo or fix mistakes and delete unwanted objects on the display.

Applications aside, the user experience was generally favorable, and participants liked the technology, if not the software. One participant noted, "It's a fun technology. It's like a Segway—it doesn't matter where you're going; it's just fun to use." The majority of groups did not enjoy the specific applications used for each task, but found the display itself fun or enjoyable to use. One participant remarked, "It was fun, but I wouldn't want to use it to get stuff done."

As a collaborative tool, participants generally agreed that a large, multi-touch display such as Lasso has a lot of potential as a collaborative tool. One participant said, "It's big enough that it's easy to approach as a group, but ultimately, you're just standing around and watching. It would be good for displaying information."

## CONCLUSION

We conducted a user test investigating how the large multi-touch display encourages people to engage in interaction, performance, and conversation in collaborative settings where two or more people perform the cooperative task together. We used two types of touch application for collaborative tasks on the large display.

### Interaction and collaboration with the large multi-touch display

This research examined how the touch interaction can support collaboration on the Lasso display. The results of questionnaires show that the large display leverages high collaboration regardless of the types of application used in our test. Through verbal communication with group members, they cooperated in ways to discover application functions together and often generated an enjoyable environment while performing the tasks. Users were generally quick to use the display; many participants showed a great amount of comfort and familiarity with the screen almost immediately. Users were generally excited and happy with the display itself.

The task performance suggests that the large multi-touch display is a promising and potential tool for supporting task-oriented work. Although Lasso and its applications have problems that diminish the efficiency of touch accuracy, speed, etc., it can potentially provide an enjoyable way for multiple user participation.

### Interaction and collaboration with singe- vs. multi-touch applications

From the questionnaire and observation results, we observed that participants paid high attention to group members' activities. When they had conflicts in simultaneous touch interaction, they assumed that the application might not support the multi-touch access. In a collaborative setting, users tended to dislike the single-touch applications, as the number of users trying to simultaneously interact with Lasso would disrupt the application and cause confusion or frustration. Using the multi-touch application the users interacted with the display more; however the tasks were much more verbally collaborative, with one person taking the lead in interacting with Lasso while the others would watch.

With regard to input condition, the participants highly preferred multiple inputs, including a mouse and keyboard. This suggests that both traditional input devices and touch interaction provide users familiarity.

## FUTURE WORK

In order to test the usability and user experience of Lasso, we had to ask that participants complete tasks using existing system applications. Consequently, this research inevitably tests the usability and user experience of the applications themselves and not just the large, multi-touch display. Future work, then, must involve user tests of other Lasso applications, in order to generalize these findings.

Additionally, this research has more qualitative data that was not covered in this paper. We will make progress to update all findings.

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