

Organized Mischief: Comparing Shared and Private Displays on a Collaborative Learning Task

Neema Moraveji, Robb Lindgren, Roy Pea, Stanford University, 450 Serra Mall, Stanford, CA 94305
Email: neema@stanford.edu, robblind@stanford.edu, roypea@stanford.edu

Abstract: We describe a study in which students in two science classes worked on a collaborative learning task using either a shared display or individual displays. The purpose is to inform how display interactions support group collaboration and individual learning when using media technologies. We examined individual learning outcomes as well as behavioral differences between students using the two display types. Preliminary results indicate collaborating with a shared display may result in more effective task organization and subsequently higher conceptual understanding.

Introduction: Networked Individualism

Much of CSCL research is concerned with the use of networked individual devices (e.g., notebook computers, PDAs, graphing calculators, etc.). Although these devices are connected such that they can support synchronous collaborative activity, the displays for these devices are private. They make up a paradigm we refer to as *networked individualism*, where individual devices are adapted into collaborative activities. Networked individualism differs from traditional collaborative activity where students discuss and manipulate a shared artifact face-to-face, can see each other's actions and make attributions, and can make gestures to establish co-reference and work to evolve a shared interpretation.

The push to create networks of distributed learners that are empowered with their own devices has to some extent diminished the important role of shared physical space in the learning process. There are relatively few attempts to utilize shared display technologies such as tabletop displays in educational contexts (e.g., Scott, Grant, & Mandryk, 2003), whereas the movement to create "networked classrooms" is spreading rapidly. The purpose of this study is to examine the process of collaborative learning using shared versus individual displays in order to determine if there are differential effects on the ability of students to coordinate their actions and construct understanding. While there have been a number of studies in which students have collaborated around a shared technology (e.g., Moher *et al.*, 2007; Stanton, Neale, & Bayon, 2002; Wilensky & Stroup, 2003) we are unaware of any study that has directly compared this practice to working through individual displays and controlled for the presented content.

The Mischief System

We were able to support a collaborative learning activity using both a shared display and an individual display by utilizing a platform called *Mischief*. A collection of mice (of the rodent variety) is called a "mischief." The Mischief software (Figure 1a) is a groupware application able to support a collection of students using wired or wireless mice. Each student has a unique cursor that can be moved around independently on a single display screen. Mischief has features that can mitigate the potential chaos of numerous cursors, and a teacher or activity leader is typically in place to guide and constrain the collaborative activities of the students. Mischief was designed to be used with a single shared display such as a classroom projection screen or SmartBoard, but for the purpose of this study we were able to use Mischief such that the collaborative (multi-mouse) activity could also be displayed on a set of distributed classroom laptops. In this case, the displays are synchronized, each individual monitor showing all student cursors and actions in real-time.

Shared Reference

The psycholinguist Herb Clark has argued for the importance of establishing referential identity in order for successful human discourse (and collaboration) to occur (Clark & Brennan, 1993). In a collaborative student learning task this means that the students must correctly identify the target of a referential act (e.g., a description, a gesture), and that the students have the *mutual belief* that the reference was understood. We hypothesized that a single shared display will be able to facilitate shared reference more effectively than the networked laptops, and that the ability to achieve shared reference will lead to greater success on the task, and possibly higher overall learning. Despite the fact that the visual presentation of the collaboration space is exactly the same for both classes, we suggest that it is easier to coordinate distributed actions and interpretations *around* a shared display rather than *through* multiple private displays.



Figure 1. (a) The Mischief system in use at a school in China. Each student has a mouse, using a single computer and display. (b) The simulation used for the task in the current study, a modified PhET simulation.

Study Design and Procedure

We designed a between-groups study to determine how a shared display versus individual display affects learning and coordinative behaviors in a classroom-size group of students on a collaborative discovery learning task. Two 9th grade science classrooms taught by the same instructor were asked to use an optics simulation distributed by the Physics Education Technology (PhET) group at the University of Colorado at Boulder. One class (13 students) worked with the simulation using a single shared display (i.e., students each had a mouse that was connected to one display projected on a screen at the front of the class). The other class (14 students) worked with the simulation using separate individual displays (i.e., students each had a laptop that displayed the same synchronous activity). In both cases the activity was collaborative and every student's cursor could be seen on screen; the only difference was whether this activity was viewed through separate displays or a single shared display. These classes were chosen because they had the same prior experience with physics and the same percentage of students who were taking an accelerated math course. Thus, there was no reason to believe that the students in these classes differed substantially in their abilities to solve optics problems prior to their participation in this study.

We modified the original Adobe Flash simulation created by the PhET group to remove several features outside the scope of our task and to integrate it into the Mischief platform, enabling multiple students to use the simulation simultaneously (Figure 1b). Each student's cursor was represented by a different animal. Most of the screen elements can be dragged and simulation parameters (e.g., index of refraction, display of primary rays) can be changed using the dials and checkboxes displayed at the top.

Each of the two classrooms received the same instructions and worked on the same tasks. The class instructor gave both classes an introductory lesson that lasted about 5 minutes in order to refresh their memory of optics concepts and terminology that would be used in the task. The experimenters then introduced the students to the simulation and familiarized them to the technology (mice or laptops) that they would be using in their condition. Students were then asked to work together to experiment with the simulation and to formulate statements or principles that characterize key relationships between elements in the simulation. For example, the first task given to students was to generate a set of rules that define where an image will appear based on the location of the object relative to the lens. Successfully completing these tasks necessitated that students develop a control-of-variables (COV) strategy: changing one variable and holding the rest constant. The class worked on each of the 3 tasks for 10 minutes, at which point they were expected to present the instructor with a consensus answer. There was relatively little teacher or experimenter intervention during the tasks except to remind students of time constraints. Screen capture and video of the students interactions were recorded for both classes.

A paper post-test was administered to each student after the 3 simulation tasks had been completed. The post-test was comprised of six questions and was completed individually. The post-test questions asked students to reason about ray diagrams, a convention for presenting optics problems that were structurally analogous to the PhET simulation. One question for example showed an object on an axis near to a lens and asked the students determine if the resulting image was real or virtual. The post-test also had problems where the students drew and reasoned about principle rays. These questions were chosen because they all required the application of knowledge that should have been generated during the 3 simulation tasks. In other words, if a class had formulated the correct principles for all 3 tasks and a student came away with a full understanding of these principles, we would expect that this student would be able to answer all the post-test questions correctly.

Results

We present preliminary results from two measures: individual post-test performance and qualitative descriptions of classroom activity extracted from experimenter field notes. On the post-test the maximum number of points is 17. Two raters, blind to condition, scored the post-tests using a common rubric. Inter-rater reliability was high

as assessed by the intraclass correlation coefficient (ICC .86 - .96). Students who used the shared display to complete the collaborative tasks had a mean score of 8.30 (SD=3.20). Students who used individual displays had a mean score of 5.96 (SD=1.87). The non-independence of student scores in a class and the small sample size prevents us from using inferential statistics to generalize about display modality. Nonetheless, the difference in mean scores indicates that the class that used the shared display demonstrated higher learning outcomes than the class that used the individual display.

As expected, both groups experienced some frustration as they became accustomed to this novel software environment. For the first task especially, students would sometimes speak simultaneously and make unsuccessful attempts to establish order. There were also points where the “multi-user” feature of this task seemed to interfere with successful experimentation. For example, while one student tried to understand a particular parameter’s effect, another student would change that parameter or a different one. Incidents like these occurred at the beginning of the session for both conditions.

While both groups struggled at first, the shared-display group was able to establish order fairly quickly. They seemed to realize that they needed to adopt a structured approach, and in fact one student stated near the end of the first task that they “need to change one [parameter] at a time” in order to understand its effect. The shared display group also determined early on that students should adopt different roles, such as “recorder”, “organizer”, and “leader.” Students in these roles made verbal requests to “stop moving [objects] without saying what you’re doing.” Students even raised their hands at certain points to be called on by their chosen leader. Compared to the individual display class, there also seemed to be a greater degree of consensus and confidence in their task answers.

Students in the individual display condition also expressed the need to implement something akin to the COV strategy, but they did so later in the session than the shared display group and it appeared more difficult for this group to enforce. When two students in the individual display condition attempted to impose leadership on the activity, they were met with substantial resistance and non-collaborative behavior. These students exhibited a generally higher amount of off-task behavior and social loafing. Even as the final answers were being recorded, some students in the individual display condition were focused on playing with the user interface on their screen. Much of the discussion in this group was dedicated to questions like “who did that?” in response to some on-screen action. Less discussion in this class was dedicated to the focal task.

Discussion and Future Directions

The higher scores on the individual post assessments in the shared display group were consistent with observational accounts of the collaborative activity for the two conditions. The individual display group had a difficult time coordinating their activity through their private laptops, and this likely hindered the individuals in this group from constructing a full understanding of the simulation relationships. These results, while preliminary, suggests an interesting trend that warrants additional analysis and further study. We are interested in looking deeper into the video recordings of each condition to uncover reasons why group and individual behavior was so divergent. To this end, we are coding attempts to establish referential identity to determine how it is achieved (or not achieved) in each group. As it stands, this study provides a solid starting point for a greater understanding of socio-technical design factors that affect learning and collaboration in large group activities.

References

- Clark, H. H., & Brennan, S. E. (1993). Grounding in communication. In R. M. Baecker (Ed.), *Readings in groupware and computer-supported cooperative work: Assisting human-human collaboration* (pp. 222-233). San Mateo, CA: Morgan Kaufmann Publishers.
- Moher, T., Ding, X., Wiley, J., Conmy, D., Hussain, S., Singh, P., & Srinivasan, V. (2003). Combining Handhelds with a Whole-Class Display to Support the Learning of Scientific Control. *Proceedings of ACM CHI 2003 Conference on Human Factors in Computing Systems* (pp. 882-883).
- Scott, S. D., Grant, K. D., Mandryk, R. L. (2003). System guidelines for co-located, collaborative work on a tabletop display. *Proceedings of the eighth conference on European Conference on Computer Supported Cooperative Work* (pp. 159-178).
- Stanton, D., Neale, H., & Bayon, V. (2002). Interfaces to support children’s co-present collaboration: Multiple mice and tangible technologies. In G. Stahl (Ed.), *Proceedings of the Fourth International Computer Supported Collaborative Learning Conference* (pp. 342-352).
- Stewart, J., Bederson, B. B., Druin, A. (1999). Single display groupware: A model for co-present collaboration. In *Proceedings of Human Factors in Computing Systems (CHI'99)* (pp. 286-293).
- Wilensky, U., & Stroup, W. (2000). Networked gridlock: Students enacting complex dynamic phenomena with the HubNet architecture. *Proceedings of the Fourth International Conference of the Learning Sciences*, (pp. 282-289).