

# Reducing Dominance in Multiple-Mouse Learning Activities

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**Abstract:** In resource-constrained classrooms in the developing world, it is common for several students to share each computer. Unfortunately, dominance behavior often naturally emerges in these situations, when one child monopolizes the mouse and keyboard. One way to mitigate this phenomenon is by providing each child with a mouse and a corresponding on-screen cursor so that everyone can interact. Though such multiple-mouse configurations reduce the possibility of total domination by one individual, they do not automatically eliminate dominance behavior completely. We propose the use of a design for small-group learning on shared computers based on enforced turn-taking in a split-screen, multiple-mouse environment. In an evaluation with 104 rural schoolchildren in India, we found that dominance behavior was indeed reduced through these design choices.

## Introduction

The standard PC was designed to be used by one person at a time. In the developing world, however, shared use of computers is the norm in schools to make access more economically feasible (Patra, 2007). When groups of students share a PC, however, it is common for one dominant child to control the mouse most of the time, often resulting in the other children becoming disengaged (Pal, 2006).

Recent attempts to address these challenges have revived the concept of using multiple mice per PC (Pawar, Pal & Toyama, 2006), an idea that originated at least 16 years ago (Stewart, Bederson & Druin, 1999). Multiple mice are plugged into a single PC and each is associated with a uniquely colored cursor, allowing many children to engage simultaneously with a single PC.

A multiple-mouse configuration, however, does not necessarily eliminate the potential for dominance behavior among students sharing a PC, any more than having a public playground eliminates schoolyard bullying. Indeed, a previous study involving the use of multiple mice in computer classrooms suggested that a dominant-child phenomenon still emerges (Pawar, Pal, Gupta & Toyama, 2007). For instance, in one game that set up children to compete against one another to answer questions, the quickest child—quick either because of mastery of the subject or sheer speed of undeterred clicking—would frequently dominate play, depriving other children of the opportunity to even register what was happening on the screen.

In this paper, we address the novel problem of reducing dominance behavior in multiple-mouse learning activities. Although there are many studies of dominance behavior among groups of children (e.g., Savin-Williams, 1979), some of which apply to computer usage (Lomangino, Nicholson & Sulzby, 1999), to our knowledge this is the first time that this question has been posed within the context of multiple mice, particularly with the pragmatic approach of reducing dominance behavior through software interaction design.

## Related Work

Previous work with multiple users simultaneously sharing a single computer and display with multiple input devices has been referred to as *single display groupware* (SDG) (Stewart, Bederson & Druin, 1999). Most early research in this area explored the use of two mice with open-ended tasks like drawing, or puzzle solving, rather than structured content-based learning (e.g., Stanton & Neale, 2003). In general, these studies found that using multiple mice in comparison to a single mouse, increased children's engagement and activity performance (Inkpen, Booth, Klawe & Uptis, 1995;).

In the past few years, several studies have focused on using SDG to improve shared computing in the developing world (Moraveji, Kim & Pawar, 2007). One study found that children easily understood the use of many mice at once and preferred to have their own mouse (Pawar, 2006). A later study found improved word retention after playing an English vocabulary learning game with multiple mice rather than one mouse (Pawar, Pal, Gupta & Toyama, 2007).

In addition to academic research, our design was inspired in part by trends in popular video games.

## Design Process and Prototyping

We followed an iterative process of user research, design and development, employing a range of qualitative research methods and prototyping ideas at finer and finer levels of granularity. We began with a literature

review and informal interviews. Prototyping then proceeded from sketches, to detailed mockups, to a working electronic prototype. The initial working prototype was tested with two groups of users in the United States: a bilingual kindergarten class and a group of eight-to-twelve-year-olds at an after-school tutoring center. This helped us arrive at a set of design decisions that formed the core elements, which we then refined during a week of informal testing and rapid prototyping in India.

### Description of the Prototypes

This section provides an overview of the most complete prototype, from which variations were developed. Based on our initial research, and consideration of factors that might reduce domination, the prototypes incorporate two main design elements: Turn-taking (to allow individuals the opportunity to interact with the computer more autonomously) and a split screen (to allow concurrent activity to proceed somewhat independently in order to minimize the potential for dominance by a single child.)

The content of the game is an English-vocabulary learning exercise, which we chose because it is a simple and familiar school task. English is taught as a subject by late primary school in almost all schools in India and is generally accepted to be a desirable subject for upward mobility (Ramanathan, 1999). Moreover, rote learning of material is common in Indian state school curricula at the grade levels we studied.

We chose to design all versions of the game for four players. Given the space limitations of crowding around a single PC, we did not want to exceed five children. Because we wanted to allow for team play, four children divided into two equally-sized teams made sense. We note that other work has suggested two (Inkpen, Booth, Klawe & Uptis, 1995), three (Zurita & Nussbaum, 2007), or five (Pawar, Pal & Toyama, 2006) as “optimal.”

The game begins with an orientation screen to help the players understand that each mouse is associated with one of the cursors (see Figure 1). The game activity begins once each player has clicked on a button specifically associated with her cursor color.

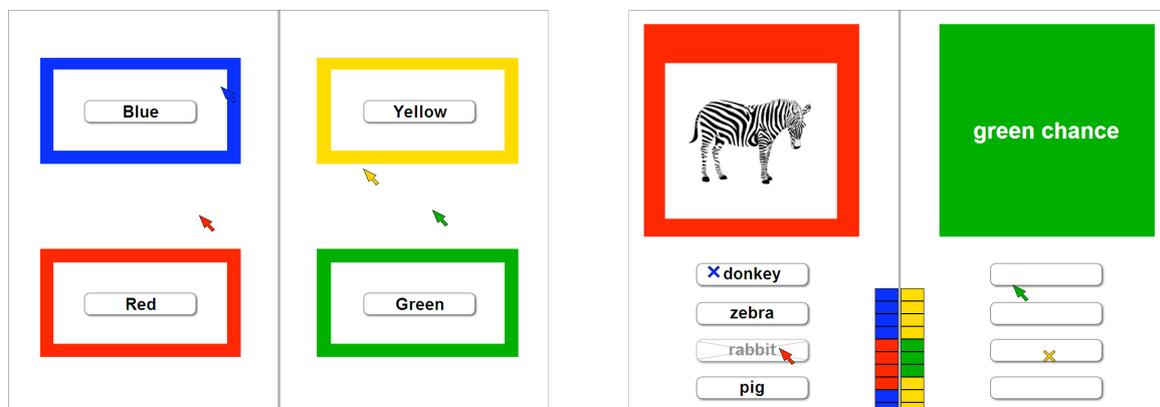


Figure 1. The orientation screen and a game in progress

The basic content of the game is an image-word matching exercise. Each question consists of an image and four buttons labeled with English words. The images and vocabulary list were borrowed from a previous study with the same population and were a good balance of familiar and new words for the target users (Pawar, Pal, Gupta & Toyama, 2007). Two questions appear simultaneously, one for each side of the screen, and the players divide into teams of two. The software then alternates turns between players within a team for every other question, and only the player whose turn it is can click on answers and get feedback.

When a user clicks on an incorrect answer, the button turns gray and the word is crossed out. When a question is answered correctly, the user is awarded points. The point scheme was designed to provide an incentive for users to answer carefully, rather than randomly clicking on buttons. Four points are awarded for a correct answer on the first attempt, three points for a correct answer on the second attempt and so on. The point bars are colored with the cursor color of the player who correctly answered the question so that each user can see how she contributed to the team’s success. The goal of the game is to build the stack of points to reach the top of the screen.

Once a question is answered correctly a new question loads and a voice pronounces the word as an additional cue to the players. To help differentiate the audio cues, all sounds for players on the left side are panned to the left stereo channel and vice versa. In addition, we recorded the word cues for the left side in a female voice and the cues for the right side in a male voice to further help avoid confusion.

### Notable Design Changes in the Field

The greatest challenge was making players aware that the game operated in a turn-taking mode. In early versions of the game, players would continue to click when it was not their turn, despite multiple cues to indicate the turn. We eventually realized the cues were too subtle amidst the excitement of game play.

We solved this problem through three changes to the turn cueing. First, instead of having a small colored box with a message to indicate the turn, we made the colored box much bigger and wrapped it around the entire image, right where users were most likely to look for a new question. Second, we made the non-active player’s cursor smaller and changed it to an X shape rather than a pointer. (We considered eliminating the cursors of non-active players altogether, but noticed that players who understood turn-taking often helped their teammates by pointing with their own cursors to suggest answers when it was not their turn.) Third, rather than immediately loading a new question between turns so that users had to simultaneously process a new question and a message about whose turn it was, we separated these into two distinct steps by adding a brief interval between questions in which only an announcement of the new player’s turn appeared.

Once children understood turn-taking, we found that they often uttered phrases such as “it’s my chance” or “it’s Red’s chance.” Discussion later revealed that “chance” is the term by professional commentators in cricket, perhaps the most popular sport in India. Consequently, we localized the interface to use “chance” wherever “turn” was used previously.

## Field Visit

We tested our prototype games with target users during two weeks of fieldwork in India, where we visited a total of six state schools in and around Bangalore. In the first week we visited three state primary schools, meeting with small groups of boys and girls of primary school age, familiarizing ourselves with representative test sites and qualitatively observing children’s play and reactions to the game. These sessions provided initial confirmation that the split screen and turn-taking made an observable difference in children’s play patterns and their articulated responses to the games. Consequently, we decided to proceed with a focus on these elements. Based on observations during the first week, we completed a final round of design improvements (see Notable Design Changes in the Field, above) and developed a standard protocol for our evaluative study.

## Evaluative Study

We conducted the evaluative study during our second week in the field, with 64 children in three schools, one in Bangalore and two in outlying villages. For the evaluative study, we defined a set of four game versions to be played by every group. This set was a stepped series in which each variation adds one design element that was not present in the previous one: split screen, one mouse per child, and turn taking. Adding one of these elements in each version made it possible to observe the effects of each independently. Table 1 compares the four game versions.

Table 1. Game Versions in the Evaluative Study

<i>Game</i>	<i>Split Screen</i>	<i>Number of Mice</i>	<i>Turn-Taking</i>
One-mouse game	No	One mouse, shared by four players	No
Two-mouse game	Yes	Two mice, one for each two-player team	No
Four-mouse game	Yes	Four mice, one per child	No
Turn-taking game	Yes	Four mice, one per child	Yes

The final set of observations included 16 groups of four children each. There were ten groups of all girls and six groups of all boys, all between the ages of 10 and 14. Each group session lasted approximately 30 minutes. The children played each of the four game versions twice in a row. The presentation order was counterbalanced, so that each group of children played the four versions in a different, randomly chosen order. Data collection included video recording, automated logging of question answering, and structured note taking. In the notes, we recorded the positions taken by the children around the screen, which child used the mouse at what time, and when control of the mouse passed between children.

## Field Observations

We draw upon both qualitative and quantitative findings to characterize the effects of the split screen, having one mouse per child and turn taking on domination and participation in game play. We have organized these observations around four aspects of the game experience: mouse control, question presentation and answering, shared participation and qualitative observations.

## Mouse Control

In games where there were fewer mice provided than players, one child often dominated play by exclusively controlling the mouse. In 20 out of the 32 one-mouse games played, one child controlled the mouse the whole

time. In half the two-mouse games one child controlled the team’s mouse throughout the game. In every one of these cases, control passed from one child to another child only between games rather than during them. Thus a dominant child would typically wrest and not relinquish control once he or she had it.

Splitting the screen into two activity areas had the potential to reduce the incidence of dominance through mouse control, by creating more, concurrent opportunities to answer questions. However, this design also introduced a risk: it might be more difficult for children to concentrate on their own activities in the game. As we show in the next section, this proved not to be an issue.

### Question Presentation and Answering

We expected that if the split screen and teams introduced difficulties for children, we would see this reflected in either demonstrated confusion during the game or reduced numbers of questions seen and answered per group. We extracted data from the game logs on the number of questions answered collectively by the four children during each game. Comparing the four game variations, we see that the split-screen game variations approximately doubled the amount of content displayed per game. Qualitatively, we observed very few instances of confusion.

In all four variations, the game ends whenever 32 points are earned. Consequently, the number of questions answered during a game varies. When the screen is split into two queues of content and children play in teams—as in the two-mouse, four-mouse and turn-taking games—more questions can be displayed and answered. Table 2 shows the comparison.

Table 2. Total questions answered per game (N = 32 for each variation)

	One-Mouse	Two-Mouse	Four-Mouse	Turn-Taking
Mean	8.9	14.6	16.4	15.7
Standard Deviation	1.0	2.8	2.9	3.5

Looking at the average game durations for each variation (Table 3), note that the one-, two-, and four-mouse games took approximately the same amount of time, indicating that teams of two children correctly answered questions at the same pace as entire groups of four children.

Table 3. Game duration in seconds (N = 32 for each variation).

	One-Mouse	Two-Mouse	Four-Mouse	Turn-Taking
Mean	34.6	33.1	35.8	53.2
Standard Deviation	9.6	8.0	11.7	11.7

### Shared Participation

Dominance by any one child in the game was reduced to the extent that multiple children participated actively. Compared to the one-mouse game, we found that for the other three games there was much greater participation by all the children in any group. In 22 of the 32 four-mouse games played, every child in the group answered at least one question correctly. Degree of domination in the four-mouse and turn-taking games was compared by measuring the differences in number of questions answered among the four group members or (in cases of team play) the pair of team members. In the four-mouse game, disparate levels of question-answering activity demonstrate that when two teammates raced to answer every question, in most cases one teammate dominated, answering the lion’s share. Game log analysis of question answering in four-mouse games shows that in the average case, one teammate answered 80% of the questions put to the team, while the other answered 20%.

Adding computer-controlled turn-taking equalized teammates’ participation. In an average team performance in the turn-taking game, question answering was almost evenly divided between teammates. In summary, the split screen and the use of one mouse per child reduced domination mechanically, through more mice and more opportunities to answer, while turn taking reduced it programmatically by providing exclusive opportunities for each child to answer.

### Qualitative Observations

Qualitative data were gathered through structured note taking and analysis of video documentation. While limited resources precluded a full translation and content analysis of the video, limited translation provided some sense of children’s exchanges. Our most notable observations concerned verbal and visual interaction among children playing together, and attitudes about group interaction expressed in post-game interviews.

*Verbal Interaction:* There were broadly two types of verbal exchange within groups. The first related to control of the mouse and occurred before the game started. The second type, typically occurring during game play, related to game content and what to answer. In exchanges about mouse control, the dominant child often

reproached another player who attempted to get mouse control at the start of a game, causing her to give up the mouse. The exchanges during play were more varied in tone and purpose, ranging from collaboration (“Up, up, now click!”) to conflict (“You be quiet, I knew three!”). Several children expressed dislike for these conflicts, explaining that this was why they preferred to play with a mouse for each. As one child put it, “If there’s one mouse we will put it to this side or... to that side or snatch it. If there are four mice we all can share equally.”

*Visual Interaction:* Children were visually very expressive and often used pointing instead of, or along with speaking to indicate answers. We found that children would effectively point only at their own side of the screen, while virtually ignoring the other side of the screen, with the exception of the score display in the center.

*Attitudes Toward Collaboration:* In contextual interviews, most children expressed a positive view of the collaborative possibilities of the games. When asked what they would do if they knew the answer but someone else had the mouse, children routinely responded, “I will tell him the answer” or “I will teach him [or her].” Potential “telling” behaviors were observed less frequently than these responses would suggest. In one-mouse games, one child typically overwhelmed all the others in advising and cueing the clicks of the child with the mouse. In split-screen games, “telling” behaviors such as talking and pointing occurred most often between teammates and rarely between children on different teams. This suggests that competition encouraged teammates to collaborate or at least communicate.

## Conclusions and Future Work

We found that our iterative design process was helpful in designing a system that adequately dealt with dominance issues. Our research offers early evidence that split-screen interfaces and turn taking have the potential to reduce dominance behaviors in small-group, co-located computer-based learning activities.

Anticipating future applications of this technology, we see the approaches of dividing the screen and automating turn-taking as potential design patterns for multiple-mouse, educational computing. We propose further design projects to validate these patterns and discover new and complementary ones (Borchers, 2001). This work would include applying these designs to more complex educational content. In addition, further evaluation is needed to determine what learning benefits, such as content retention or enhanced positive interdependence among the group, can be gained through the design approaches we have introduced.

## References

- Borchers, J. O. (2001). A pattern approach to interaction design. *AI & Society*, 15(4), 359-376.
- Inkpen, K., Booth, K. S., Klawe, M., & Uptis, R. (1995). Playing together beats playing apart, especially for girls. *Proceedings of CSCL*, 95, 177-181.
- Lomangino, A. G., Nicholson, J., & Sulzby, E. (1999). *The Nature of Children's Interactions while Composing Together on Computers*. CIERA Report.
- Moraveji, N., Kim, T., Pawar, U. (2007). "A Mouse on Each Desk: An Inexpensive Classroom Interaction Technique for Remote Teaching," Microsoft Research Technical Report, Redmond, WA.
- Pal, J. (2006) Early-stage practicalities of implementing computer aided education: Experience from India. *Proc. of TEDC 2006*.
- Patra, R., Pal, J., Nedeveshchi, S., Plauche, M., Pawar, U. (2007). Usage Models of Classroom Computing in Developing Regions. *Proceedings of ICTD 2007*, 158-167
- Pawar, U., Pal, J., & Toyama, K. (2006). Multiple Mice for Computers in Education in Developing Countries. *Proceedings of ICTD 2006*.
- Pawar, U. S., Pal, J., Gupta, R., & Toyama, K. (2007). Multiple mice for retention tasks in disadvantaged schools. *Proceedings of the SIGCHI conference on Human factors in computing systems*, 1581-1590.
- Ramanathan, V. "English is here to stay: A Critical Look at Institutional and Educational Practices in India" *TESOL Quarterly* (1999) Vol 33:2 pp 211-231.
- Savin-Williams, R. C. (1979). Dominance Hierarchies in Groups of Early Adolescents. *Child Development*, 50(4), 923-935.
- Stanton, D., & Neale, H. (2003). The effects of multiple mice on children's talk and interaction. *Journal of Computer Assisted Learning*, 19(2), 229-238.
- Stewart, J., Bederson, B. B., & Druin, A. (1999). *Single display groupware: a model for co-present collaboration*. ACM Press New York, NY, USA.
- Zurita, G., and Nussbaum, M. (2007) A conceptual framework based on Activity Theory for mobile CSCL, *British Journal of Educational Technology*, 38 (2), pp. 211-235(25)

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