Drag-and-Drop vs. Point-and-Click Mouse Interaction for Children

Kori Inkpen, Kellogg S. Booth, Maria Klawe
Department of Computer Science
The University of British Columbia
Vancouver, British Columbia, V6T 1Z4, Canada
+1 604 822 8990
inkpen@cs.ubc.ca

ABSTRACT
This paper presents the results of a study on girls' and boys' usage of two common mouse interaction techniques. The two techniques, *drag-and-drop* and *point-and-click*, were compared to determine whether one method was superior to the other in terms of speed, error rate, and preference. For girls, significant differences between the two methods were found for speed, error rate and preference. *Point-and-click* was faster, fewer errors were committed, and it was preferred over *drag-and-drop*. For boys, a significant difference was found for speed but not for error rate or preference. *Point-and-click* was faster than *drag-and-drop*, the errors rates were comparable and, although more boys preferred *point-and-click*, the difference was not significant.

Keywords
Interface design, input techniques, computers in education, drag and drop, children, gender.

INTRODUCTION
Today's children will be the adult computer users of tomorrow and their interactions with computers today will shape their future relationship with technology. As pointed out by Fulton Suri [2], "with the rapid growth of computer systems in home environments we need to expand our focus to ensure that interactions with computers have a positive impact on child development". But how can we ensure that computers have a positive impact on child development? An important first step is research in human-computer interaction focusing specifically on children.

Children are now exposed to computers from a very early age. The types of interaction techniques used in children's software are quite varied. In general, children appear to adapt to whatever interaction style is present, but leaving this adaptation to chance is not the best approach. In order to design effective interaction techniques, "we need to use a deeper understanding of task, device, and the interrelationship between task and device from the *perspective of the user*[italics added]" [9]. There has been significant research on interaction styles for adults, but until recently very little research has focused on children's interactions with computers. Adapting to the perspective of children as users means that we cannot just assume that children are young adults. It is important to investigate a variety of issues, through empirical methods, with children as users. Indeed, researchers have begun to notice that some of the prominent user-interface styles designed for adults may not be appropriate for children [1,14].

It is true that many children are computer whizzes, able to perform amazing feats that their parents can only envy. But what about the child who is not comfortable with a computer? What about the children who are timid, unsure, or insecure about their computer abilities? Giving these children an interface style that is inefficient, awkward, or frustrating could have a detrimental effect on their computer experience. Children could be inhibited by the interaction style a particular programmer decided to implement in some software, simply because there are "no ergonomic standards available regarding children's specific user-interface needs" [2].

In 1990, Shneiderman, in a paper titled "Future Directions for Human-Computer Interaction", listed some common goals for interactive systems: increased productivity, reduced error rates, easier learning, and more consistency in performance [13]. He went on to state that these goals are easily measured. If this is true, why have these goals not been evaluated for systems designed for children to use in educational environments? Shneiderman also listed several broader goals, two of which have particular relevance in the context of children: improved user satisfaction, and increased sense of self-worth [13]. Our study compared two common interaction styles to determine which mightresult in increased productivity, reduced error rates, more consistency in performance, and improved user satisfaction.

Our research was motivated by a previous study we performed that showed a significant difference in achievement and motivation between girls playing two different versions of the same commercial computer game, *The Incredible Machine* [7]. The two versions of the game were identical except for their interaction styles. The results of our earlier study showed that girls using a *point-and-click* implementation on an IBM-compatible computer were able to solve significantly more puzzles and were more motivated to play than girls using a *drag-and-drop* implementation on a Macintosh computer.

This previous research demonstrated that the interaction style used in a piece of software can have a significant impact on the usefulness of that software, especially if the software is to be used in an educational environment. Because the method of movement for all objects in the *drag-and-drop* version of the game was not consistent, we designed our follow-up study to isolate the movements of *drag-and-drop* and *point-and-click* in order to focus on inherent differences in the two interaction styles, not on any other artifacts of the game software.

Previous research conducted in 1991 on adults showed that dragging was slower than pointing and that more errors were committed during a dragging task than a pointing task [11]. We chose to re-examine this issue because of changes in user experiences due to the prevalence of direct manipulation interfaces today as compared to 1991, and because it is important to explore this issue with children in case their needs are different from those of adults.

METHOD

Subjects and Setting

The subjects in this study were 68 children (36 girls and 32 boys) between the ages of nine and thirteen. The study took place at Science World BC, an interactive science museum in Vancouver, British Columbia, during a three day period in August, 1996. A research booth was set up on the second floor of Science World in an open area commonly passed by visitors. Small risers were used to section off the experimental station so that people passing by could not crowd around the subjects. All subjects were visitors to Science World BC who volunteered to take part in the study.

Procedure

The children were required to move boxes around on a computer screen using a mouse. Two different user-interaction styles were used: *drag-and-drop* and *point-and-click*. The movement required picking up a solid green box located on the right hand side of the screen and moving it over to an outlined red box located to the left of the original green box (see Figure 1). During the movement, visual feedback was given by a small iconified filled green square attached to the cursor (see Figure 2).

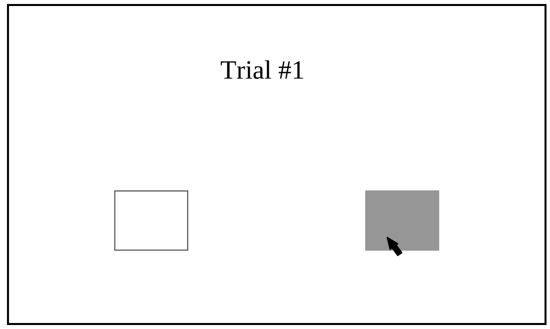

Figure 1. Subjects picked up the solid (green) box and placed it on top of the (red) outlined box.

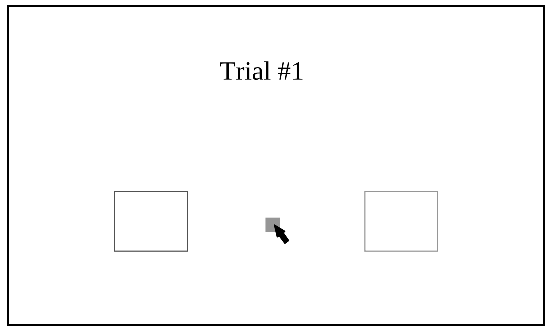

Figure 2. Visual feedback during either a *drag-and-drop* or a *point-and-click* movement. A small iconified picture of the solid green box is attached to the cursor as the box is moved.

The *drag-and-drop* movement required the children to position the cursor over the solid green box and press the mouse button down. While maintaining pressure on the mouse button, the cursor was then moved over to the outlined red box and the mouse button released to drop the green box.

The *point-and-click* movement required the children to position the cursor over the solid green box and press and release the mouse button. The cursor was then moved over to the outlined red box (maintaining pressure on the mouse button was not necessary) and the mouse button was pressed and released again to drop the box.

The solid green box (the *source*) was one of two sizes (32 pixels or 64 pixels), the outlined red box (the *target*) was also one of two sizes (32 pixels or 64 pixels), and the distance between the two boxes was one of two distances (300 pixels or 700 pixels). Each combination of source × target × distance appeared twice in a sixteen trial block. Four of the sixteen trial blocks were completed by each subject for both interaction styles.

The computer produced an audible beep when a successful drop had occurred and a new set of boxes would then appear for the next trial. After each block of sixteen trials, the screen would go black to give the user a break between blocks. The researcher would then press a button to progress to the next block of sixteen trials.

Before beginning each interaction style, the subjects were given a practice block to become familiar with the mouse movement. The children were instructed to complete the movement as quickly as possible without making too many mistakes.

The order of the interaction style was counterbalanced for each gender and all trials were completed by a subject in one fifteen minute period.

Upon completion of a trial, the children were asked to rank their preference of interaction style on an eight point scale. To facilitate this procedure for children, a pinwheel was used. The pinwheel consisted of two different colored cardboard circles, each divided into eight pieces. Both circles were slit and then placed together so that a portion of each circle could be seen [6]. For example, the pinwheel could be turned to show three pieces of one circle and five pieces of the other (see Figure 3). Each interaction style was given a specific color and the children were required to turn the pinwheel to indicate which interaction style they preferred.

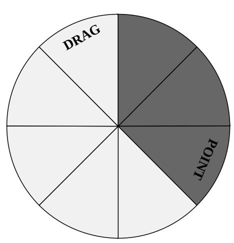

Figure 3. Pinwheel used for children to rate preference on an eight point scale.

The computer recorded the time for the movements as well as the number of errors committed. The errors were classified into two categories: pickup errors and drop errors. Pickup errors were errors committed while trying to pick up the source (i.e. missing the solid green box). Drop errors were committed if the target was missed (i.e. the button release in *drag-and-drop* or the button press in *point-and-click* were not in the target area). Timing in a trial began with the first attempt to pick up the source and ended when the box was successfully dropped in the target. Timing averages were computed two ways: (1) not including trials with errors, and (2) including trials with errors. The reason for this will be explained in the next section.

RESULTS

Movement Times

The results for average movement times with and without error trials included are shown below. In both cases, *point-and-click* was significantly faster than *drag-and-drop*. No difference was found between average movement times for boys and girls in either interaction style.

The difference between the average times for *point-and-click* and *drag-and-drop* significantly increased when error trials were included ($p<.001$).

Analysis Case 1: Times Not Including Errors

A significant difference was found between the time to perform a *drag-and-drop* operation and the time to perform a *point-and-click* operation for both girls and boys (see Table 1).

Table 1. Timings for *drag-and-drop* and *point-and-click* movements when error trials were not included in the times

	Drag	Point	Sig.	Effect	Power
Girls	1341ms	1270ms	p<.05	.18	74%
Boys	1301ms	1243ms	p<.06	.11	48%

Analysis Case II: Times Including Errors

A significant difference was found between the time to perform a *drag-and-drop* operation and the time to perform a *point-and-click* operation for both boys and girls (see Table 2)

Table 2. Timings for *drag-and-drop* and *point-and-click* movements when error trials were included in the timings.

	Drag	Point	Sig.	Effect	Power
Girls	1672ms	1386ms	p<.001	.36	99%
Boys	1568ms	1364ms	p<.001	.36	99%

Distance, Source Size and Target Size

In the repeated measures analysis, the factors of move distance, source size, and target size all had a significant effect on the time for the movement. It was significantly faster to move objects to a closer target than to a target farther away, $p < .001$. It was significantly faster to move a larger source than a smaller source, $p < .001$. It was significantly faster to move to a larger target than to a smaller target, $p<.001$. All of these results had large effect sizes, whether or not the error trials were included. This performance result is predicted by many other studies, and is typically modeled by Fitts's Law [4].

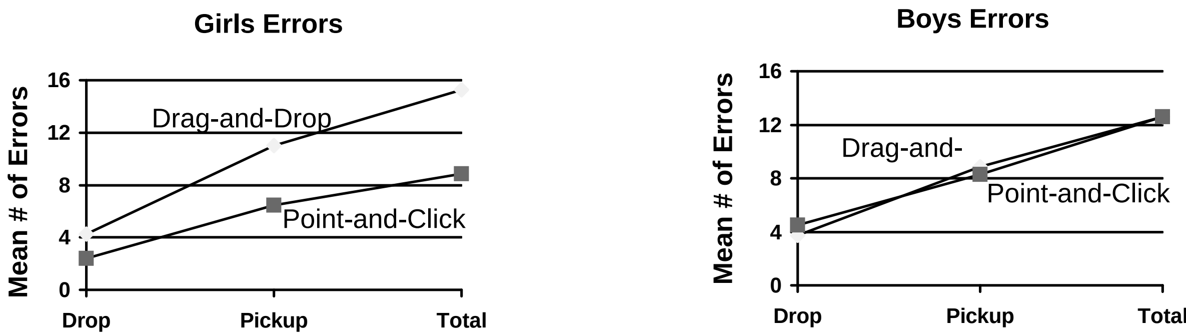

Figure 4. Line graphs representing the difference in the number of errors between the interaction styles for girls and boys.

Errors

The average number of errors committed were divided into three categories: total number of errors, number of errors committed while dropping an object, and number of errors committed while picking up an object. A summary of the three categories of errors is shown in Table 3.

Table 3. Mean number of errors committed

		Total	Drop	Pickup
Girls	Drag	15.28	4.25	11.03
	Point	8.86	2.42	6.44
Boys	Drag	12.58	3.73	8.85
	Point	12.79	4.52	8.27

For the total number of errors and the number of drop errors, girls committed significantly more errors using the *drag-and-drop* method than using the *point-and-click* method, $p<.05$ and $p<.01$ respectively. The effect sizes for the total number of errors and drop errors were .144 and .24, respectively. The difference between the pickup errors was marginally significant, $p<.06$, with an effect size of .11. There were no significant differences found between the number of errors committed in the two interaction styles for boys. Figure 4 shows the average number of errors committed for each interaction style for both boys and girls.

Preference

Table 4 shows the percentage of children who preferred each interaction style. Significantly more girls preferred the *point-and-click* method than the *drag-and-drop* method, $p<.001$. Although more boys did prefer the *point-and-click* method over the *drag-and-drop* method, this difference was not significant. Figures 5 and 6 show the breakdown of the children's ranking of interaction styles.

Table 4. Children's preference of interaction style

	Drag-and-drop	Point-and-click	No Preference
Girls	19%	72%	8%
Boys	39%	58%	3%

DISCUSSION

As in previous research, *point-and-click* was found to be a significantly faster movement than *drag-and-drop*, for both genders. 38% of the children specifically commented that they found the *point-and-click* interaction style easier to use than the *drag-and-drop* style.

In contrast to previous research, *drag-and-drop* did not have more errors than *point-and-click*, when used by boys. Girls, on the other hand, committed significantly more errors using *drag-and-drop* than *point-and-click*. On average, however, girls committed fewer errors than boys when using the *point-and-click* interaction style, while they committed more errors than boys when using the *drag-and-drop* interaction style.

If only trials in which no errors were made are used to compute the average time for the movements, *point-and-click* is on average 65ms faster than *drag-and-drop*. Because this difference is quite small, it is unclear whether or not having an interaction method that is milliseconds faster than another will produce noticeable differences in task performance. The real performance difference comes from observing the trials in which errors occurred.

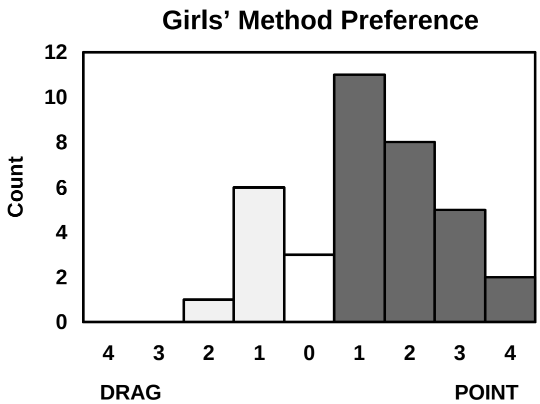

Figure 5. Girls' ranking for preference of interaction style

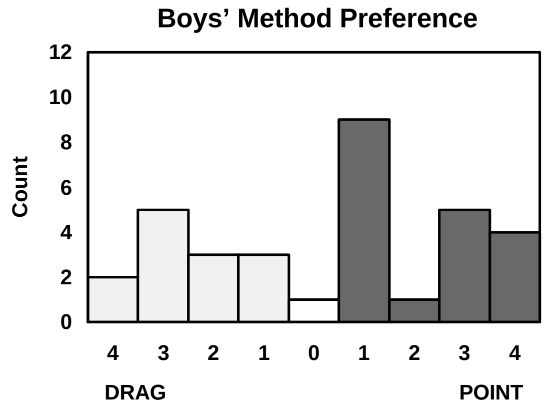

Figure 6. Boys' ranking for preference of interaction style

The children in this study made errors on approximately 15% of the trials. The children's sole focus in this study was to move the source box over to the target box. However, in an educational setting, such as the previous study with *The Incredible Machine*, the child is concentrating on the goal to be achieved instead of on the interaction method itself. The child could be trying to decide where to place an object in order to satisfy the goal, or starting to think about the next move in the game, thus paying less attention to the movement itself. We would expect the error rates to increase as the cognitive load of the actual task increases.

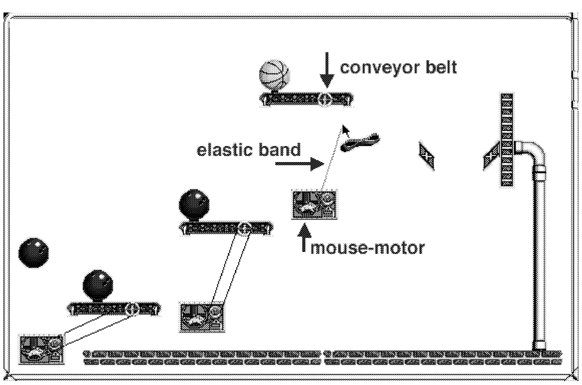

Figure 7. Game screen from The Incredible Machine showing the connection of an elastic band between a mouse motor and a conveyor belt [15].

The game in which differences were found between the two interaction styles in the earlier study was *The Incredible Machine* [7]. Children often had difficulty placing an elastic band between two objects, such as a mouse-motor and a conveyor belt (see Figure 7). The difficulty that arose is illustrated in the following example of an analogous real world task.

The task might be to tie a rope between two trees. In real life, you would throw the rope around the branch of one tree, walk over to the other tree and throw the rope around one of its branches. If you missed the branch while attempting to throw the rope to the second tree, you could catch the rope and attempt the throw it again. In the *point-and-click* movement, this is exactly what happens. If you miss the target area when dropping the object, the object stays attached to the cursor, ready for a second try. Because the *point-and-click* movement is two discrete actions (one click to pick up the object, one click to drop the object), failure during only one of the actions does not require repeating both actions. Buxton refers to these two discrete actions as atomic tasks and suggests that they might be chunked together into a single action [3].

Error recovery during *drag-and-drop* movement is more complicated. The action is one physical motion (press the button down to pick up the object, release the button to drop the object). In this case, the unit tasks have been combined together into one gesture [3]. If the target is missed while releasing the button, it is not possible to release the button again until the button is again depressed. In some particular tasks, it is not appropriate to leave the object in an incorrect position. In our rope example, it is not possible to tie a rope to thin air. Therefore, the only alternative is to return the object back to its original state, before the motion began. This requires the child to go back to the beginning to pick up the object again, and re-attempt the drop.

It is the error recovery process that seems to expand the gap between the two interaction styles. By including the trials in which errors occurred, differences between the movement times for *point-and-click* and *drag-and-drop* increase significantly. Instead of an average difference of 65ms between the two interaction methods, the average difference increases to approximately 250ms. The time to complete a *point-and-click* movement with only one drop error increases the time by 47%, on average, while during a *drag-and-drop* movement, the time increased by 154%, on average.

The method for handling errors has another implication: user satisfaction. Significantly more girls preferred the *point-and-click* method of interaction, which could be attributed to the fact that girls had significantly more errors when using the *drag-and-drop* interaction style. A significant correlation was found between the method in which the girls committed more errors and the method they preferred, $p<.05$. Many of the children expressed that they did not like the fact that if you missed the target during the *drag-and-drop* motion, you had to start all over again.

The children were all asked why they preferred one method of interaction over another. 53% of the children who preferred the *point-and-click* interaction style explicitly stated it was because it was easier than *drag-and-drop* while 37% of the children who preferred the *point-and-click* interaction style complained that the *drag-and-drop* interaction style made their finger or hand tired, keeping the mouse button down. Other researchers have also reported that children have difficulty maintaining pressure on the mouse button [14]. For children who preferred *drag-and-drop* over *point-and-click*, 47% stated that it was because they were more familiar with *drag-and-drop*. They explained that software they commonly use at home involves dragging. Another reason given for why *drag-and-drop* was preferred by some was the tactile feedback given. The children knew that they were dragging the box when their finger was maintaining pressure on the mouse button. This notion is supported by Buxton who explains that a kinesthetic connectivity can help to reinforce the conceptual connectivity of the task [3].

CONCLUSION

The results of this study suggest that utilizing a *point-and-click* interaction style in children's software would be more effective than using a *drag-and-drop* interaction style, especially for girls. Children are able to perform the action faster, they make equivalent or fewer errors, and many of the children we studied prefer it. Girls, in particular, made significantly fewer errors with *point-and-click* and significantly more girls preferred the *point-and-click* interaction style to *drag-and-drop* in our study.

We examined the interactions styles of point-and-click and drag-and-drop for the task of moving a box from one position to another. The point-and-click interaction style decomposes the task into two atomic task, pick up the object and drop the object. The drag-and-drop interaction style attempts to "chunk" the tasks together into one physical motion. According to Buxton, significant benefits can be achieved by binding concepts and gestures [3]. Buxton suggests grouping tasks together by tension and closure, with tension implying muscular tension. The difficulty with this approach for children, as suggested in this study, is that the physical difficulty of performing the combined gesture may outweigh the benefits achieved from conceptual feedback.

This study examined two common interaction styles for mouse-based input. The results are significant because at the present time, the mouse is a major input device for computers found both at home and school. Whether or not the mouse is an appropriate input device for children is another question which future research should investigate.

The focus of this research has been to find an effective mouse interaction style that children find easy to use, a style in which few errors are committed and one that children prefer to use. In some cases, failure to provide these elements may interfere with the cognitive task that is being performed. However, in some educational environments, where the aim of the software is to stimulate children's reflection on the educational concepts, researchers have found that "awkward interfaces" can help to promote awareness of the concept being learned [12,5].

This study is a part of a large-scale project on Electronic Games for Education in Math and Science (E-GEMS). E-GEMS is a collaborative effort among scientists, mathematicians, educators, professional electronic game and educational software developers, classroom teachers and children. The goal of E-GEMS is to increase the proportion of children who enjoy exploring and learning math and science concepts through the use of electronic games. Within the scope of the E-GEMS research, we recognize that in order to achieve the overall goals of the project, we must understand how children interact with the technology.

It is important to investigate how computer environments effect both girls and boys. Previous research in E-GEMS has shown that girls and boys interact differently in electronic environments [8,10]. In this study, there was no significant difference between the performance for boys and girls with respect to timing of mouse input. The differences that did arise were the errors and preferences between the two interaction styles for girls. By focusing on gender while studying the effects of technology, we will help to gain a better understanding of both female and male users.

Continued research on human-computer interaction issues for children is important. Only through this research can we gain an understanding of how computer systems and software can be effectively designed for children and what kind of impact this technology is having on their lives.

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