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Playing games on the screen:

Adapting mouse interaction at early ages

J. Enrique Agudo
University of Extremadura
GExCALL group
Mérida, Spain
jeagudo@unex.es

Héctor Sánchez
University of Extremadura
GExCALL group
Mérida, Spain
sasah@unex.es

Mercedes Rico
University of Extremadura
GExCALL group
Mérida, Spain
mricogar@unex.es

***Abstract*— Technology is changing the way today's children learn. Based on our experience in the development of educational software for children, it is our belief that computer interaction should consider the factors that affect children´s cognitive abilities and take an active part in the realm of the methodological process of hypermedia design. Departing from the results of a preliminary study with pre-school children, serious difficulties regarding mouse interaction when playing computer games are detected, mainly in the movements requiring more complex psychomotor abilities, such as double click and interactions leading to dragging the cursor. The evaluation reports on the need to adapt the mouse interaction to children´s cognitive development, from point-and-click to drag-and-drop, and the suitability of introducing intermediate variations adapted to young learners' needs.**

Keywords- Mouse interaction; children; usability; early ages

I. COMPUTER INTERACTION AT EARLY AGES

Technology is integrated into the preschool curriculum to entertain and foster learning in a multi-sensory environment in which children can experience "learning by doing". Nonetheless, although nowadays children are exposed at a very young age to new technologies (portable video consoles, cell phone, etc.), the hardware and software interface is at times simply inappropriate for little ones [1][2].

Very young children process and interact with the information at a slower rate than adults since their skills are further determined by cognitive factors and psychomotric abilities. Thus, when handling an input device, it seems reasonable to conjecture that youngsters can adjust their responses if given more time, space and training and if a device doesn´t make greater demands on their capacity throughout the whole process.

An illustrative example would be the kind of fine-tuned response required by a joystick which moves beyond the cognitive abilities possessed by a three-year-old [3]. On the same token, the traditional type keyboard represents a device calling for revision as it requires an abstract connection between the object on the monitor and pressing the keys [4].

According to [4][5], it seems that although children can and do in fact use the mouse in a fairly efficient way, they prefer to use the keyboard The attraction may be due to an implicit desire to explore as the keyboard offers considerably more options than other entry devices. However, when older, they choose the mouse as being the more efficient device appropriate to their skills and age.

In this sense, usability studies on input devices carried out on 3-5 year-old children, comparing the mouse, the keyboard, joystick, trackball and touch screen, conclude that the mouse is the most efficient input device [4][3][6].

The total process in terms of time for psychomotor skills requiring mouse movement is determined by Fitts' Law which states that the time needed to move the mouse is directly proportional to the target distance and inversely proportional to the size of that target [7]. With early ages this means that the larger the object, such as a button or other graphic / textual component of the interface, the faster the child can perform interactions; likewise, the smaller the object, the slower the interactions, with the added consequences of potential frustration and/or failure. In research with 4-5 year-olds conducted by Hourcade et al. [8], it was concluded that objects of 64x64 pixels offered significant advantages over objects of 32x32 and 16x16 pixels with regard to improved precision and in avoiding re-entry into the object once it had been reached.

Certain interaction styles and mouse types are far too challenging for little hands. Strommen [9] claims that smaller children experience difficulties in maintaining buttons pressed for too long a time as well as with coordinating 'drag' and 'click' operations. Inkpen's study [10] showed that children performed better and also preferred interfaces of the interaction point and click over the drag and drop style. These findings were backed by a study [11] conducted with ten 2-5 year-old children which revealed that "drag and drop" interactions are particularly difficult for children under 4, and still somewhat laborious for children above this age. In an attempt to solve the problems manifested by drag and drop, Cairncross et al. [12] proposed an innovative format: if the child should release the mouse button before arriving at its final destination, it would freeze where released and could be picked up again in the same position.

In addition, children have trouble with a double click on the multi-button type mouse device [13], as well as with differentiating buttons on the left from buttons on the right [14][12]. For the young child to reach skilful mouse management, the software should provide a progressive increase in steps beginning with an introduction to mouse movements. Once the child has a command of mouse movements, other actions like pressing buttons can be

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gradually introduced [15]. Since objects requiring "drag and drop" or "double click" demand complex skills they should not be introduced at all in order to avoid unreachable expectations that would only result in frustration for the young learners.

In the light of this, developmental stages should be accounted for in satisfying needs and preferences that change with growth. It stands to reason that by minimizing the skills required to complete the processes for functioning with an input device, educators can help children become more involved on their own terms with computer based activities[16][17].

II. MOUSE INTERACTION

Based on the assumption that educational software addressing Primary school learners must comprise a set of features to encourage access and development [6], it is our purpose to study and adapt the mouse interaction style in computer games to the dexterity of children by examining, in general terms, how comfortable children feel while using the mouse and the number of mistakes they make.

As far as the initial child-computer (mouse) interaction design is concerned, we have departed from children's cognitive and motor abilities, establishing as our main premises: (1) interaction should be as simple as possible, including the three main kinds of interaction (click, double click and drag and drop) and (2) the need to train young learners with the basic movements of the mouse (dexterity in pressing buttons, the expertise with different types of interactions and so on).

A. Preliminary study

The 3-5years old participants of this preliminary research had to complete the games included in unit 1 (hello¡) of our system (SHAIEX), a 7 unit hypermedia system for language learning at early ages (Figure 1)[18][19].

Figure 1. SHAIEX game

The games, included under the types: *sticker, choose, matching, pop the Balloons* and *coloring*, are designed according to 3-5 years old children's main characteristics (variability on the educational level, differences on the cognitive abilities and level of dexterity with the mouse, device interaction analysed in the present study).

The mouse interaction included in the games under research was designed according to three general interaction levels: click, double click and drag and drop. However, we decided to include an additional type of interaction, placing the cursor, since we had previously observed that in a click action there were children who had serious problems placing the mouse cursor on the objects. The key is to enable progressive training with the mouse in the games, which becomes more or less complex depending on the advances made by the child.

Thus, once the games were designed following the aforementioned parameters (educational and linguistic content, cognitive abilities and mouse adaptation level), we found it necessary to evaluate the functionality of the games in class, assessment which would serve to corroborate their adaptation to the type of user, and also to introduce changes in future editions of the system where necessary.

Our research was conducted in the preschool classroom of three different schools in Extremadura (south-western Spain). The total number of children participating in this research was 42, and their age rank was distributed as follows: 10 three-year-old children; 21 four-year-old children; 11 five-year-old children.

The results from the preliminary study are shown in Fig. 2., where, in general terms, you can see the percentage of children that have problems, according to age, in the different types of interaction under study (place, click, double click and drag and drop).

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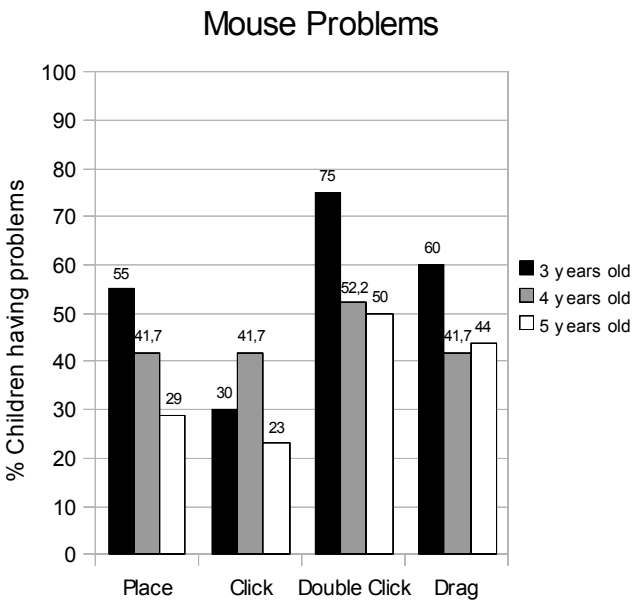

Figure 2. Mouse problems in the preliminary study.

From the results, we can state that there are serious difficulties regarding the mouse use in the three levels under examination (three, four and five year-old children), mainly in the movements requiring more complex psychomotor abilities, such as double click and interactions leading to dragging the cursor. Keeping in mind that at this age it is

normal to have difficulties to master the mouse because they are still developing their motor skills, a similar percentage of students in the three schools refer to their difficulty to interact and follow the navigational options in the games.

In detail, the research indicates that the click movement can be performed by children of all ages with the least amount of difficulty, the highest percentages being in four years old, around 40%, mainly because the main problem for three year old children in a click action is placing the mouse cursor on the object, therefore a new variant (*Point*) is included in further stages.

The difficulty involved in the last two types of interaction (double click and drag and drop) alerts us of the need for revision of games design in all the age levels, leading us to consider the possibility of including adaptive/intermediate interaction parameters in order to ease the movements.

However, we observed improvement in the adapted interaction parameters as the child's age increases, especially in more complex interaction movements such as double click and drag and drop, ranging from 75%/60% of difficulty in the case of 3 year old children when double-clicking or dragging to 52.2%/50% and 41.7%/44% in the case of 4 and 5 year olds respectively. Consequently, we can state that despite the fact that there are serious difficulties to master the mouse, as the youngsters get older, their mouse management capacity is sharpened.

Likewise, one of the main problems encountered after the interaction analysis was the child's lack of conceptual understanding, making it difficult, for instance, the comprehension of a matching exercise asking to relate animals and places because of the lack of knowledge children had of the different natural habitats.

B. *Finding solutions*

Based on the results of the preliminary study shown above, it seems clear that mouse operations can be complicated for children, showing, among other conclusions, that proper training is needed, mainly with all those who have no previous experience in the use of computers. For this reason, adapting the use of the mouse, the introduction of intermediate variations from the 3 general types were decided upon as follows in table I.

Through the adaptation and the intermediate variation, we will customize the student's interaction with the educational games, starting first with all the variants included in a click interaction type (point /roll over and click) and introducing gradually drag and drop and double clicking interactions as children increase their dexterity with the mouse. The tool is basically run via the integration of a tutoring system connected to a hypermedia setting so that users may advance within the units and games at their own pace.

These different interactions (main types and variations) are subsequently introduced into the different games, so depending on the type of activity children can practise each skill gradually, easier at first and more complicated later. The new types of interaction need to adapt to the educational level of the children involved in order to promote progressive learning in handling the mouse.

TABLE I. INTERMEDIATE VARIATIONS

Main Interaction	Sub-Interactions
Click	Point
	Roll Over
	Click
Double Click	Double Click (Long pause)
	Double Click - move
	Double Click – move - Double Click
	Double Click
Drag and Drop	Click – move
	Click – move - Click
	Drag and Drop

Thus, once the new interaction variants had been designed and programmed, our research went back to the preschool classroom, to evaluate how they work with young learners and whether instructors may need to return to refining requirements, or if they can continue with the pre-arranged interaction. It is our purpose that the evaluation ensures, as far as possible, that the final product meet early learner's needs and usability parameters.

C. *Mouse adaptation: interaction results*

On returning to the same pre-school classrooms, we set out to field test mouse management with computer games by incorporating the newly created interaction types in the tasks to be undertaken by the sample target group. In this case, the overall number of children participating in the research was 60, distributed as follows: 14 three-year-old children (23%); 27 four-year-old children (46.7%), and; 19 five-year-old children (28.3%).

Several study sessions were developed between November 2007 and January 2008, using an adaptive version of the hypermedia system with the first three units (Hello!, The Body and My Family). The children started with basic interaction activities (point and click), moving gradually on to double click activities and drag and drop movements. The key aspect of the adaptive version is to provide progressive training with the mouse, enabling users to advance within the lessons at their own pace, depending on the progressive achievements.

Figure 3 shows, in general terms, the percentage of children that have problems with the use of the mouse according to age level, and compares the results obtained in the preliminary study (in grey) with the adaptive solution of intermediate mouse variations introduced in this phase.

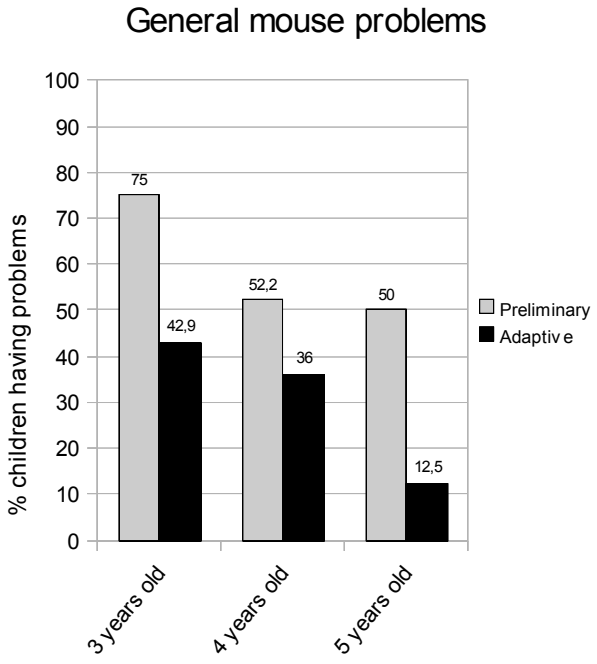

Figure 3. Mouse problems with adaptive games

As seen in Figure 3, regarding the difficulty the child experiences when applying the newer mouse interaction to respond to the activities, we notice that a significant reduction in problems has occurred in comparison to the first study at all levels and very significantly in three and five years.

Furthermore, we can ascertain that problems diminish with the increase in the age of the children due to greater experience and a better development of psychomotor abilities, data which was not so clear in the preliminary study.

To keep on tracking the main problems when handling the peripheral device under study, the main difficulties that arose when moving the mouse were analyzed. Figure 4 shows the percentage of children that have problems with the different interactions of the adaptive version (in black in comparison with the results from the preliminary study (in grey).

As we can see, the percentages derived from the introduction of the adaptive version are 15.6%, 15.6%, 48.2% and 51, 87% (related to placing the cursor, clicking, double clicking and dragging and dropping, respectively), higher than those obtained from the non-adaptive evaluation of the preliminary study. (Figure 4).

From the information shown in Figure 4, we can deduce that adapting the type of interaction to the educational level of children and introducing progressively an increased level of difficulty in mouse interaction -the so-called intermediate variations in table 1-, we should be able to reduce problems and minimize the number of mistakes they make. Although we can see there is a clear decrease in problems with point and click (at this initial stage children are still learning how to use the mouse), the main advances are found in double click and drag and drop, stages in which children have already acquired some expertise and control with the mouse.

We also point out that we will most likely come across difficulties at this age level, motivated by limitations in child development, however they are considered within normal expectancy and pertinent to the gradual fulfillment of the learning process.

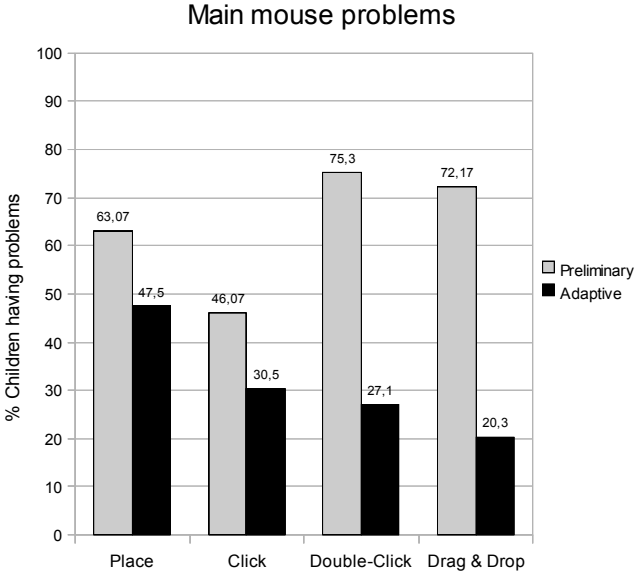

Figure 4. Main mouse problems

III. CONCLUSIONS

Educational software targeting primary school learners must comprise a set of features to fit the children's level of knowledge, interaction skills and adapt to their cognitive needs and competencies. Due to their special characteristics regarding cognitive and psycho-motor development, a chief consideration should be also focused on the capacity to function with this medium at early ages. Usability can be consequently measured both by its functional utility and by its design style, features ever so crucial with implementation in very young learners.

In this sense, training is revealed as a powerful enhancement which allows users to navigate and interact with the content progressively, requiring attention on interaction with the input device. Results of the evaluation sessions with the hypermedia system could easly be assumed and generalized to other systems applied to young learners. With this purpose in mind, empirical testing with pre-schoolers on site renders valuable information like determining efficiency correctors needed to enhance individual learning.

From the results we can state that by introducing intermediate variations for learning how to use the mouse and adapting these variations to the dexterity of the children we can minimize the number of mistakes made with the

mouse and increase learning, especially at early ages due to their developmental stage.

Thus, the questions that arise in empirical research provide clues as to what makes a good design and is therefore considered the most valid way of integrating technology suited to such an early age group

IV. FURTHER DEVELOPMENTS

Nowadays, devices such as mobile phones, PDAs, tablet PCs, and touchpad Computers or EeePC Top are fully integrated into our society. They are making debuts in classrooms alongside digital boards. Users interact with these mobile devices by directly touching the screen or with handheld optical pencils. There are already several research studies analyzing the usability of these new consumer interfaces [20][21][22]. In an effort to extend the intelligent tutor of SHAIEX towards a completely personalized format of education which respects the individual characteristics of the user, we are currently working on the adaptation of SHAIEX presentation and interaction styles to the mobile device so that interaction modes allow for expedient communication with the educational software.

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