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Age-Based Interface Design for Children's CAPT Systems

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***Abstract*—**Children today use computer based application in various activities especially for learning and education. Many of these tools and application such as the Computer Aided Pronunciation Training (CAPT) systems enable children to explore and experience them with little supervision from the adults. In order for these tools and application to have maximum effect on the children's learning and education, it must be attractive to the children to use them. This could be achieved with the proper user interface (UI) design. As children grow, so do their ability, taste and preferences. They interact differently with these applications as they grow older. This study reviews several articles on how age factors influence the UI design. The review focuses on age related abilities such as cognitive, literacy, concentration and feedback requirement. We have also evaluated few of existing CAPT systems and determine the influence of age-based factors on the interface design.

***Keywords*—**Children, age-based interaction, learning application, age-based UI.

I. Introduction

THERE are many systems developed for children in the area of learning and education such as the Computer Aided Pronunciation Training (CAPT). CAPT system allows children to practice their pronunciation with little assistance from the adult. CAPT system is suitable to be used by children as it offers private, stress-free environment in which children can access effectively unlimited input, practice at their own pace and, through the integration of Automatic Speech Recognition (ASR), receive individualized and instant feedback [1], [2]. A good UI can increase the frequency of usage of the system which will ultimately improve the pronunciation and communication of the children [3]. When developers design the interface, they fail to consider the fact that the need of children differs from the adult. Most of existing CAPT system's interfaces were designed by adults, and may not consider the exact requirement by the children. On top of that, the design of interface for children of a particular age bracket may not fit in well with other age bracket. To make the CAPT system more attractive to children with different ages, the interface design must be flexible and adapted to children of different ages. When the interface suits the children's need and wants, the rate of usage increases and this will speed up the improvement to the children's speech pronunciation.

The focus of this paper is to review the importance of age-based factors in the interface design. In our research, we reviewed researches conducted on different types of children's technology for different age groups developed by different researchers. Some of the significant differences among the children of different ages are cognitive, literacy, concentration and feedback requirement. We have concentrated our study on CAPT systems by evaluating several of the existing CAPT and determining the influence of age based factors on the UI design.

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II. Age Factors in the Interface Design for Children

It has been reported in several researches that one of the biggest challenges of designing interactive experiences for children is creating age-appropriate experiences including the content, functionality, interactions, and visual design [4]-[6]. Researchers found that there are many challenges faced when designing with children, and they differ with different age groups. This is not surprising given the quick rate at which young children develop cognitively, emotionally, and socially. It is logical that techniques that work for a 13- year-old would not work, or at least need to be modified in order to work, with a 4-year-old [7]. In this section, we review some of the age-based factors such as cognitive, literacy, concentration and feedback requirement.

A. Cognitive and Mental Development

Cognitive refers to the ability of the children to remember the steps when using UI. Due to massive cognitive development during their growth, younger children have a lower cognitive ability than the older children [8]. Developer should avoid using concepts unfamiliar to children such as referring to left and right part of the screen for younger children. Instructions should be made in such a way to be easily remembered by the children [8]. Researchers have found that it is important to provide young children with opportunities to discover, be creative and solve problems [9]. Cognitive development benefits significantly from children's involvement in creative thinking and problem solving activities. Druin et al. [10] observed that when designing children's UI, the designer should always consider the fact that children may not yet understand abstract concepts. They found that the children were unable to form queries but were able to understand the icons representing what animals eat, the

place they live and their appearances.

III. Literacy

Literacy refers to the ability of children to read. Younger children usually have less developed reading ability as opposed to older children. In [11], they suggest three issues in literacy which are (1) difficulty in understanding and using the alphabetic principles, (2) failure to transfer the comprehension skills of spoken language to reading and to acquire new strategies that may be specifically needed for reading and (3) absence or loss of an initial motivation to read or failure to develop a mature appreciation of the rewards of reading. To address these challenges, Hanna et al. [8] suggests presenting information based on age appropriate format so as to deal with different levels of literacy. They also suggest that designers of children's technology should always include the option of providing text instructions read aloud since younger children are not used to reading on the screen. Since there is a significant difference in reading and writing proficiency, children's interface must be designed in a narrow age-group in mind so as to meet the needs of its users. In [12], they have developed the graphical Story writer which provides some unique learning opportunities for early readers (four to seven years old). They found that graphical metaphors are helpful for children's interaction with computers. Druin et al. [10] have studied the digital libraries for children and discovered that typical text-based query interfaces were not satisfactory for young user's needs. Their research strengthens the idea that content specific, graphical metaphors are proper representation for children and visual interfaces with least text are more suitable for younger children.

IV. Feedback and Guidance

It is a delicate task to present just enough information about the system without overwhelming the user and at the same time give enough information so that the user can understand the difference between his/her performance and the goal [13]. Therefore, it is important to use feedback that is clear, useful and motivating for the children.

Children always expect to see the effects of their actions instantly; if nothing happens after their input, they may keep on repeating the same action until something occurs. It is important to avoid adding instructions in children's interface during design. Children cannot be expected to read a manual to learn how to use a product; the product must either be completely intuitive or it should provide some form of guidance through tasks [14].

Engwall et al. [13] evaluated a prototype for the human-computer interface of a computer based speech training aid, ARTUR, with two user groups' aged nine to fourteen and six years old children. They found out that the older children easily understand the feedback given to them on how to alter the articulation especially the written or the oral instruction while the younger children had difficulty in understanding such kind of feedback.

In [15], they identified three interface elements that play an important role in reflective thought; representation, interaction protocol and feedback. They have found that representation plays a vital role in how people think about objects and concepts. Representation should be supported by proper interaction and feedback to give room for construction of deeper operational and structural understanding of the representation concept. Children four to seven years find it difficult using the first system they developed as it had no visual or audio feedback to indicate that an object was properly selected. The children keep on selecting same object expecting that something would happen. They always clicked on buttons multiple times which usually leads to unexpected results when the series of commands executed [12].

V. Concentration

It is observed that to design software that satisfies the needs of huge variety of kids is very difficult because of individual age differences. Some kids easily get bored; some need more motivation while others need specific education target. Moreover, what works for seven year olds may not necessarily work for nine year olds as they have different level of concentration [5]. In [13], it was found that children may forget how to accomplish tasks that require several steps or even simple tasks that are performed rarely. They used a menu model in which menus are not visible on the screen in order to save space on the small display. They must select a soft-button to bring up the menu. Children find it difficult to remember the action to bring up the menu; they commented that they would prefer the menu that is visible on the screen just like the traditional desktop.

VI. Summary

Table I summarizes the age based factors from the review we have conducted and how they differ between the young and older children.

TABLE I
Summary of the Age Based Factor from the Review of Literature

Factor	Young Children	Older Children
Cognitive	Lower	Higher
Literacy	May not understand alphabets at all	Can read but may not develop the adequate comprehension
Feedback	Quick and frequent feedback	Feedback that acknowledge their participation
Concentration	Low	Fair

VII. Review on the Existing CAPT System

Based on the age-based factors identified in Section 2, we have evaluated some of the existing CAPT systems to determine whether the IU design of those applications consider the age-based factors.

VIII. Application

We have accessed 10 CAPT systems [14]-[33] for various languages and evaluated them based on the factors that we have discussed in Section II. The CAPT systems used in this research were the one that is freely available for research

purpose and commercial use. Fig. 1 shows the language breakdown of the 19 CAPT systems evaluated in this research (some of the CAPT are for more than one language). The majority of the CAPT selected in this research was design for English, Spanish and others.

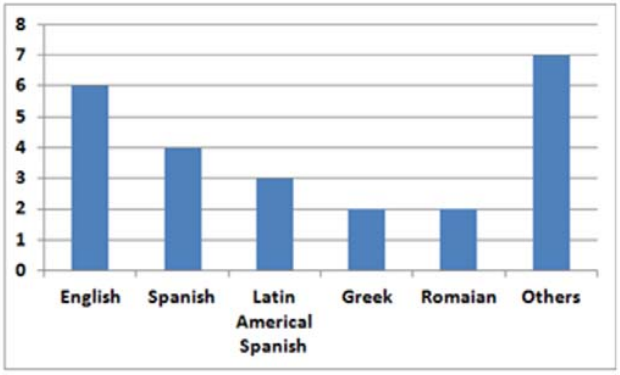

Fig. 1 The language breakdown of the 19 CAPT systems evaluated in this research

IX. Findings of the Review

Table II shows the number of CAPT systems that have considered the factors discussed in Section II in their UI design. While most of the CAPT (15 of them) did not consider all of the factors, we have several of them that considered all four factors (4 CAPT systems).

TABLE II
THE NUMBER OF CAPT SYSTEM THAT HAVE CONSIDERED THE AGE BASED FACTORS

Factors	Considered	Not-Considered
Cognitive	11	8
Literacy	13	6
Feedback	15	4
Concentration	6	13

Among the four factors, the majority of the CAPT systems evaluated have considered the age factors in their system feedback. The existing CAPT design includes variety of feedback that caters for children of different ages. The feedback provided by the majority of the CAPT caters to the specific age group so that the children knew their current performance and how they can improve further. For example, several of the CAPT employ a 3D facial animation to assist the younger children the correct way of pronunciation by showing lip and tongue motion. Other form of age based feedback includes the use of audio and visual feedback, where the audio feedback shows the correct way of pronunciation and visual feedback indicates the degree of correctness from the user's pronunciation. We found that there were a few CAPT systems that did not consider the age factor in their feedback, which may be too complex for younger children. One of the CAPT draws two spectrograms based on the children speech, the first one show the correct way of pronunciation and the second one shows the child's actual pronunciation. This form of feedback in our point of view is too complex for the children to understand and overcome their mistakes. The second factor that was considered by most of the CAPT is the level of literacy of the children. Some of the existing CAPT provide both text-based display as well as voice based interaction for younger children with poor reading ability. We also found that some of the CAPT use pictures and symbols as a replacement for text-based display. In a number of CAPT, the wordings were made with bigger font, so as to make it easier for the children to read. For the cognitive factor, almost half of the CAPT we have evaluated did not consider the cognitive and mental development of the children. In the literature, the mental development and memory power of younger children is much lower than older ones. However, we notice that the number of steps to operate the application was the same for both younger and older children in several CAPT. On top of that we found that some CAPT did not consider age appropriate words or sentences making younger children to have difficulties in pronunciation of the displayed text or pictures. The least considered factor by 19 CAPT systems is the concentration. Although most of the systems are designed with an effective feedback and attractive UI, the majority of the CAPT did not fully consider that the younger children have poorer concentration and can be easily distracted. A number of the CAPT systems incorporate animation or characters that can attract the children especially the younger ones.

X. Conclusion and Future Direction

The user interface and the ways of interacting with computer-based systems are critical for the use and performance of each system. Poorly designed interface could lead to poor usability and problematic to the target users. The UI for children should reflect their mental model and the physical, physiological, and psychological abilities, which changes drastically as they get older.

In this study, we found that there are several age-based factors that were considered in the existing literature which are cognitive, literacy, feedback and concentration. These factors were found to be critical when designing children's learning applications.

We found that some of the age-based factors have been considered when designing the UI for children. Factors such as feedback and literacy were adequately addressed in the UI design of most CAPT systems evaluated in this research. However we found that the factor of concentration is neglected by most of CAPT. One reason is that it is very difficult to design UI that can attract the children and more so to kept them glued to their seats when using the CAPT. The use of animation or characters can attract the younger ones, but may not be suitable for older children.

The CAPT system aims at improving the pronunciation skill of children of different ages. Although age specific CAPT could solve the age based issue, developing individual CAPT for specific age is both time consuming and costly.

Based on our review and evaluation on the existing CAPT, we are suggesting that the CAPT UI should be flexible to cater

for the different age group. For younger children, the CAPT UI should be more on sound based and picture based, with the use of animated characters, and more simple steps to learn their pronunciation skill. On the other hand, for older children, the CAPT UI can display text based material as the mode of interaction, and use more icon but less animated characters,

Having age based UI which can apply specifically to different age group can increase the usage among the children as the UI caters specifically for the need and the ability of children of different ages. Increase in usage of CAPT will help to improve the pronunciation of these children.

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