Age-based factors in the interface design of CAPT systems for children

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Abstract

Today's children are using computer based application in various activities especially in learning and education. Many of these tools and application such as the Computer Aided Pronunciation Training (CAPT) system allow children to enjoy the learning process with little supervision. For these applications to have a maximum effect on children's learning and education, it must be attractive to the. This is achievable with appropriate 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 has reviewed several articles on how age factors influence the UI design. The review focuses on age related abilities such as cognitive, literacy, concentration and feedback. A team of six individuals evaluated several existing CAPT systems to determine the influence of age-based factors on the interface design. From our evaluation, we found that most of the CAPT systems have incorporated age-based feedback and literacy. However, many of the CAPT systems fail to consider the age-based factor of concentration in their UI design.

Index Terms: Children, age-based factor, learning application, age-based interaction

1. Introduction

Children are increasingly using computer technologies in various parts of their lives including education, entertainment and so on. The user interface (UI) is recognized as an important mechanism that governs the interactions between human and computers. As users interact with the computer through the interface, it is very important to design a suitable interface for the intended users [1].

There are many systems developed for children in the area of learning and education and one of them are the Computer Aided Pronunciation Training (CAPT) system. CAPT system allows children to practice their pronunciation with little assistance from the adult. Through the integration of Automatic Speech Recognition (ASR) system, the children receive individualized and instant feedback [2, 3].

A good UI can increase the frequency of usage of CAPT system which will ultimately improve the pronunciation and communication of children. When developers design the interface for children, they fail to consider that the need of children differs with the adult. Most of the existing CAPT system's interface were designed by adults, and may not consider the exact requirement of children. On top of that, the design of interface for children of a particular age bracket may not fit well with other age bracket. To make the CAPT system more attractive to children of different ages, the UI design should be flexible 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 have reviewed research conducted on different types of children's technology for different age groups. 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 system by evaluating several existing ones and determining the influence of age-based factors on the UI design.

2. Age factors towards UI design

It has been reported in several researches that 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 UI for children, and they differ with different age groups. The most common groups identified in the literatures are the six to ten (elementary school) and 11 to 14 (Secondary school) [7-10]. This is not surprising given the quick rate at which young children develop cognitively, emotionally, and socially. It is logical that technique that work for a 13- year-old would not work, or at least need to be modified to work, with a six year-old [11]. In this section, we review some of the age-based factors such as cognitive, literacy, concentration and feedback requirement.

2.1. 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 lower cognitive ability than the older children [12]. When designing UI for younger children, the UI should be designed with simple and easy to understand concept. For example, Hourcade et al., [13] reported that young children prefer learning from texts containing large number of pictures and relatively few words. Instructions should be made in such a way to be easily remembered by the children as most of the younger children have low memory capacity as compared to the older children [12].

Researchers have found that it is important to provide young children with opportunities to discover, be creative and solve problems [14]. Cognitive development benefits significantly from children's involvement in creative thinking and problem solving activities. Druin et al., [7] observed that when designing children's UI, the designer should avoid the use of abstract concepts as children may not yet understand the 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.

2.2. Literacy

Literacy refers to the ability of children to read. Younger children (six to ten years) usually have less developed reading ability as opposed to older children (11 -14 years). In [15], 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 this, Hanna et al., [12] suggest presenting information based on age appropriates 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. The use of speech based interaction benefits children with poor literacy.

Since there is a significant difference in reading and writing proficiency, children's interface must be designed in a narrow age-group in mind to meet the need of its users. In [16], 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., [7] 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 is more suitable for younger children. On top of that the use of read-aloud system can be very helpful to the younger children.

2.3. 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 [17]. 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, they may keep on repeating the 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 [8].

Engwall et al., [17] evaluated a prototype for the human-computer interface of a computer based speech training aid, ARTUR, with two user groups' aged nine to 14 and six years old children. They found out that the older children easily understand the feedback on how to alter the articulation especially the written or the verbal instruction while the younger children had the difficulty in that kind of feedback.

In [18], 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 users 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 concepts.

Children four to seven years find it difficult using the first system developed in [16] as it had no visual or audio feedback to show 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 [16].

2.4. Concentration

Design software that satisfies the needs of variety of children is very difficult because of individual age differences. Some children easily get bored; some need more motivation whiles others need specific education target. Moreover, what works for seven years old may not necessarily work for nine years old as they have different level of concentration [5].

Concentration is achievable by giving the children more autonomy when using the system. Some of the ways to promote better concentration includes allowing the children's actions map directly to the actions on the screen and let the children be in control of the actions they perform [7,8].

2.5. Summary

Table 1 summarizes the age-based factors from the review we have conducted and how they differ between the young and older children.

Table 1. *Summary of the age-based factors from the review.*

Factor	Young Children (six – ten years)	Older Children (11-14 years)
Cognitive	prefer simple and easy to remember display	can handle more steps due to improved cognitive and memory
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

Figure 1 shows the screenshot of a UI that consider the different age groups for children users. By selecting the appropriate age bracket, the system will selects the age appropriates UI and feedback.

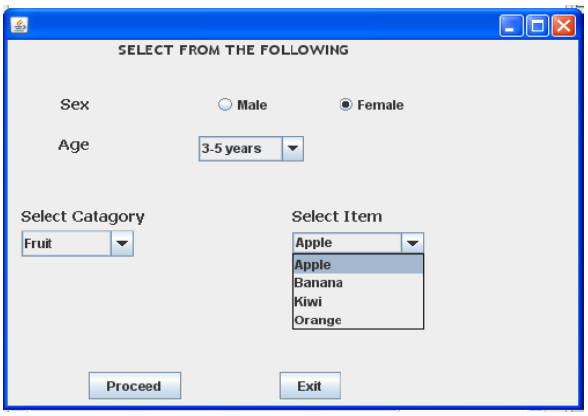

Figure 1: *Example of system that is designed with UI for children with different age groups [9].*

3. Review of the existing CAPT systems

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. The UI age appropriateness is evaluated by individuals that have experience with children's ability to interact with computers including teachers (2 respondents), UI experts (2 respondents) and the authors. Each respondent review the interface and score them for age-based factors in the UI design. The score range from 0 to 2 (0: no consideration, 1: some consideration and 2: full consideration). The scores provided by the evaluators are based on the guidelines shown in table 2, which was derived from the identified age-based factors.

Table 2. *Guidelines for evaluating the UI for age-based factors.*

Factors	Guidelines for evaluation	Six to ten year	11-14 years
Cognitive	Use the graphical metaphors	✓	✓
	Use visual interfaces	✓	✓
	Abstract concept	×	✓
Literacy	Using familiar terms	×	✓
	Text –based query	×	✓
Feedback	Use audio or visual feedback	✓	✓
	Display score of children performance	✓	✓
Concentration	Children's actions map directly to the actions on the screen	✓	✓
	Be in control of the actions they perform	×	✓

✓ Positive effect on children's interaction × Negative effect on children's interaction

3.1. Application

We have assessed 19 CAPT systems [8, 17, 19-36] for various languages that are freely available for research purpose and commercial use and evaluated them based on the factors that we have discussed in section 2. Fig. 2 shows the language breakdown of the 19 CAPT systems evaluated (some of the CAPT systems are for more than one language). Most of the CAPT systems selected in this research were design for English and Spanish.

4. Findings of the review

Table 3 shows the scores of the CAPT systems' UI based on the guidelines set in table 2. For CAPT system with score from 0 -0.99, it is categorized as "not-considered" the age-based factor in their UI design. For the CAPT systems that have score from 1.00-2.00, they are categorized as "considered" the age-based factors in their UI design. While most of the CAPT systems (15 of them) did not consider all the factors, some do consider all the four factors (four CAPT systems).

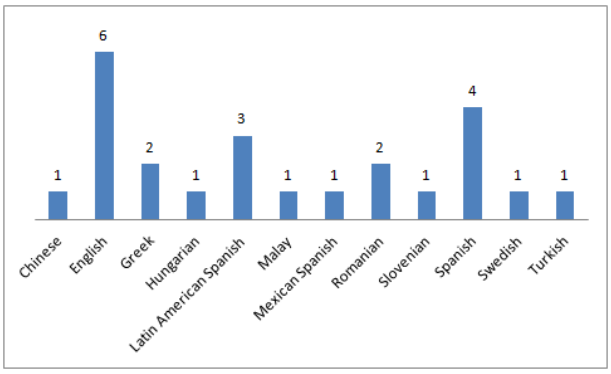

Figure 2: *The language breakdown of the 19 CAPT systems evaluated in this research.*

Table 3. *The number of CAPT systems that have considered the age-based factors.*

Factors	Considered (1.00-1.99)	not-Considered (0.00-0.99)
Cognitive	11	8
Literacy	13	6
Feedback	15	4
concentration	6	13

Among the four age-based factors, most of the CAPT systems have considered the age-based feedback in their system [17, 21, 22, 23-26, 29-33]. The average score for this factor from the review is 1.61. The existing CAPT systems design include variety of feedbacks that cater for children of different ages. The feedback provided by most CAPT systems 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 systems employ a 3D facial animation to assist the younger children the correct way of pronunciation by showing lip and tongue motion [23, 26]. Other forms of age-based feedback include the use of audio and visual feedback, where the audio feedback shows the correct way of pronunciation and visual feedback shows the degree of correctness from the user's pronunciation [29-33].

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 systems [20] draws two spectrograms based on the children speech, the first one shows 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 systems is the level of literacy of the children with an average score of 1.49 for the 19 CAPT systems. Some of the existing CAPT systems provide both text-based display as well as voice based interaction for younger children with poor reading ability [17, 19-23]. Several CAPT systems that we have evaluated make use of pictures and symbols as replacement for text-based display [26, 28]. In some CAPT systems, the wordings were made with bigger font, to make it easier for the children to read [17, 19-23].

Almost half of the CAPT systems we have evaluated did not consider the cognitive and mental development of the

children [26-33]. In the literature, the mental development and memory power of younger children are much lower than older ones. However, we notice that the number of steps to operate the application were the same for both younger and older children in several CAPT systems. On top of that we found that some CAPT systems did not consider age appropriate words or sentences making younger children to have difficulties in pronouncing the displayed text or pictures [27, 28].

The least considered factor by the 19 CAPT systems is the concentration (average score of 0.97). Although most of the system is designed with an effective feedback and attractive UI, most of the CAPT systems did not fully aware that younger children have poorer concentration and can be easily distracted. Several CAPT systems incorporate animation or characters that are attractive to the younger children [17, 27].

5. Conclusions and future directions

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 literatures which are cognitive, literacy, feedback and concentration. These factors were found to be critical when designing children's learning applications.

From our analysis of the existing CAPT systems, we found that some of the age-based factors identified have been considered in designing the UI for children. The 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 systems. One reason is that it is very difficult to design UI that can attracts the children so to keep them glued to their seats when using the system. The use of animation or characters can attract the younger ones, but may not be attractive enough for older children.

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

Based on our review and evaluation on the existing CAPT systems, we are suggesting that the UI should be flexible to cater for the different age groups. For younger children, the UI should focus more on sound based and picture based, with the use of animated characters, and simpler steps to learn their pronunciation skills. On the other hand, for older children, the UI can display text based materials as the mode of interaction, and use more icons but less animated characters.

Having age-based UI which can be applied specifically to different age groups 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 systems will help to improve the pronunciation of these children.

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