iCAN: *A Tablet-Based Pedagogical System for Improving the User Experience of Kids with Autism in the Learning Process*

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***Abstract*—Paper-made Picture Exchange Communication System is the conventional pedagogical approach for developing the communication skills of kids with autism. Unfortunately, its disadvantages greatly increase the burden of caregivers and damage the experience of users. To overcome these problems, our multidisciplinary team produced iCAN, a tablet-based APP system that combines the successful aspects of the paper-made PECS approach and advantages provided by electronic device and contains several features to smoothen and ease the learning process. Eleven kids with autism participated in the experiments to examine iCAN. The change of their user experience demonstrates its benefits as Orange technology.**

***Index Terms*—Autism, User Experience, HCI, APPS, Design**

I. Introduction

Autism is a dire illness which hinders the proper development of cognitive functions, social skills, and communicative abilities of children with Autism Spectrum Disorder (ASD) [1]. CDC in US reports that one out of one-hundred fifty children is affected with ASD and suffered from adapting to social life.

One of most effective pedagogical techniques for assisting children with autism is the Picture Exchange Communication System (PECS), a tool developed by educational experts for supplementing their communications with others. The PECS system is primarily composed of picture cards, each with an image and a description of either an object and action or an emotion, Figure 1, and the effectiveness of PECS lies in children with autism being able to use these picture cards to make sentences that express what they need or how they feel to their caregivers.

Fig. 1. Example of a figure caption.

Since its inception, the PECS system has been an invaluable resource for both children with autism and their caregivers.

Despite of the efficiency of PECS as an educational tool and for the development of cognitive abilities, our user experience research revealed a variety of issues with the system including three specific major problems in user experience (UX):

- Creation: The general approach of creating picture cards with computers, printers cards, laminating machines is resource-intensive and time-consuming.
- Portability: The space needed to store picture cards increases as students gain greater knowledge. Carrying enough cards for daily communication is burdensome.
- Management: The collection of picture cards are difficult to manage and search for. The delay in locating the appropriate picture cards creates a communications gap between children with autism and their caregivers.

We devised iCAN to alleviate these problems and enhance UX through the utility of tablets. They provide both convenience and portability factors, and enable seamless interaction between children with autism and their caregivers at both the instructional and communications level.

The process followed a research-through-design paradigm [2] and consists of three stages, UX research, UX Design and UX Testing. The goals of iCAN are to reduce teaching burden and the burden of producing cards for caregivers and to enhances learning motivation and improve learning processes for Kids with Autism. The differences of the changes of UX will be showed.

In the following sections, we first describe the related work, and give a brief overview of iCAN. Then, we present the method on examining UX differences. Lastly, we showcase our results from our user study that caregivers' burden were reduced and the differences between user experience were discussed in terms of ISO definition of UX.

II. RELATED WORK

Caregivers play a crucial role in the lives of children with autism because of unique cases presented by each child of autism. Parents of children with autism especially report typically higher levels of stress and stronger symptoms of depression compared to parents of either normally-developed children or children with other types of disabilities [3].

Prior research work from the HCI community have investigated various ways in how computers can better assist children diagnosed with autism. Not only have an extensive portion of those works focused on improving those children's cognitive, community, and social skills, but most of these computer-assistive systems have also focused on facilitating some of the developmental deficiencies of children with autism [4][5].

The Spoken Impact Project (SIP) [6] targets the communications aspect of children with autism and demonstrated the potential of utilizing computer-generated audio and visual feedback to encourage the children's spontaneous speech-like vocalizations. [7] focused more on the caregivers by empowering parents and educators to first create and develop complex models of social scripts, having the potential to help content-creators as they create a social skills instructional module. [8][9] have similarly focused on enhancing the social and communication skills of children with autism. vSked [10][11] involved each student utilizing multiple individual devices, reduced the number of prompts provided by teachers and aides, and improved the transition time communicated between the student and teacher. PixTalk [12] served as a portable PECS-based assistive tool in helping children with autism communicate. It is more restrictive to children due to the needs of cognitive capabilities and finger manipulating capabilities.

Most of current Tablet-Based PECS Systems place greater emphasis on being communication-assistive tools for helping children with autism express themselves to their caregivers, while iCAN instead places greater emphasis on being a teaching-assistive tool for developing the communications skills of children with the aid of their caregivers.

Moreover, previous systems emphasis on how these children convey their messages across, but iCAN takes into account the caregivers as part of target users and their user experience on how they can support the children in their communications development skill. In terms of UX, one major problem of current systems is the lack of language support for Chinese. The inherent linguistic and cultural contrasts between the English and Chinese languages demonstrate the benefits of iCAN for the UX of Chinese users, for example, automatic grammar correction when making sentences. Therefore, we examine the differences between UX.

III. THE DESIGN PROCESS

The design process was fundamentally based on user experience in three different stages.

Deployment: The collected information from these preliminary interviews in the exploration stage was then collated for use in formulating concepts to incorporate into designing iCAN's initial working prototype. We then deploy our prototype to our test users of caregivers for reviewing its capabilities and verifying its usability with children of autism. Refinement: We lastly refined our system from feedback received from the previous deployment stage, where our system was installed onto a tablet device for user testing. In collaboration with special education instructors and therapists, we assessed the effectiveness of our refined iCAN.

UX Research: The design team first collected the UX problems of how children with autism learn communications skills through existing system.

The information was collected using ethnographical interview. The major finding was the inconvenient UX for children and caregivers in using paper-based picture cards or electronic communication boards. For caregivers, the task of creating paper-based picture cards is a time-consuming and tedious process. A card would roughly take 10 minutes to make. One caregiver expressed in the interview that "I did not know you would ask this. I dare not to recall my memory of this. In the beginning they (father and another son) would help, but gradually they felt very tired. I was left along in making all these cards". Just image how many hours it would take to produce 200 cards which are basic amount of learning communication.

For children with Autism, more picture cards created over time in response to growing vocabulary knowledge, more difficult are storing and transporting them. Individual cards were prone to being lost. Searching for the appropriate card to use during communication was not immediate, especially for a larger collection of picture cards. This tended to increase the anxiety when trying to express themselves. For both children and caregivers, the current electronic communication boards were hard to use with bad UX.

UX Design: To resolve the problematic UX issues, the designers started a long journal of exploring best UX for the children with Autism and their caregivers for two years until now. The initial features of iCAN include the followings.

- A real picture card that could pronounce when being pressed. In terms of UX, the pronunciation is in Chinese, so enable Chinese users to utilize. Moreover, a word needs to be pronounced more than 100 times to be remember by children of Autism. This was a great burden for the caregivers. With iCAN, children can learn by themselves and thus give the caregivers great relief, a excellent UX in teaching for them. In terms of the presentation of categories, we have combine three visual features to increase the UX, and each category has label, color, and small pictures because children with Autism tend to have better abilities to recognize colors and pictures. The structure of categories was established with the help with Children Psychologists to produce better UX, as shown in Fig. 2.

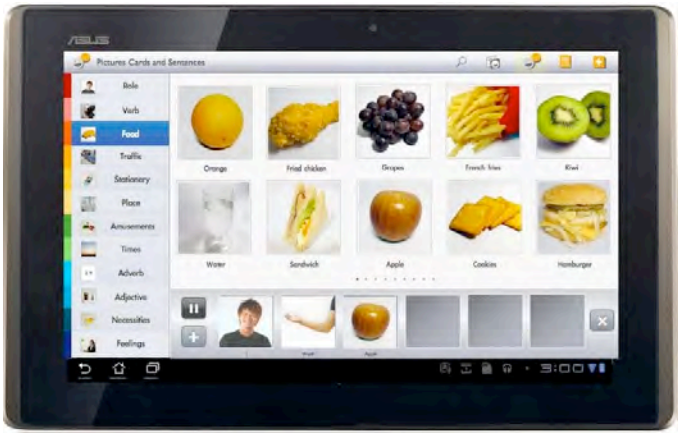

Fig. 2. The user interface of iCAN

- Sentence Making by long pressing the needed picture cards After learning basic vocabulary, a further step is to learn sentences. Traditional paper cards make the process very unfriendly, for example, difficulty to search the needed cards and inconvenience to record the progress of sentences teaching. For better UX, iCAN provides an easy way to make sentences and they could be recorded for future rehearsal. Moreover, long pressing, not drawing, cards to make sentences for better UX because some children with Autism could not control their hands preciously. Long pressing create better UX in this scenario, as shown in Fig. 3.

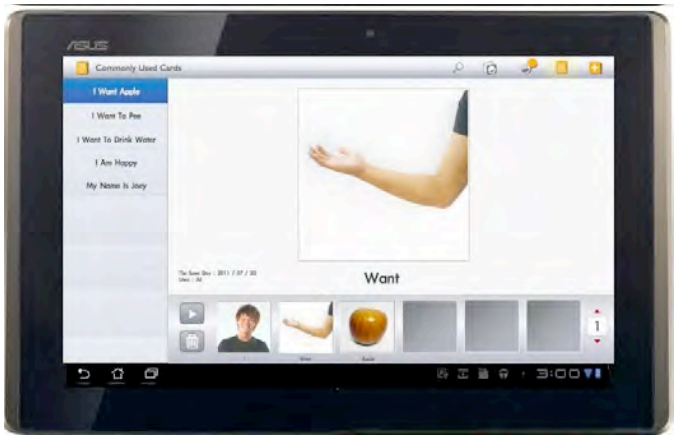

Fig. 3. Sentence making of iCAN

- Given the vast amount of time needed by caregivers to construct new paper-based cards through the papers and printer, this process is exhausting and even painful to them. iCAN utilizes the tablet device's built-in camera and microphone hardware for enabling caregivers to easily create new digital picture cards in minutes. This function created a significant affect on UX. For example, some children with Autism could remember better when using pictures of their own products or relatives.

UX Testing: After setting up the features of iCAN, we finish the first version of iCAN in forms of conceptual prototype established by powerpoint. The iCAN 1.0 was then used to conduct the first UX Testing with children with Autism and their caregivers. They provided some feedbacks based on the simulated UX. Using them, we then produced the iCAN 2.0 and simulated by Keynote. This version could be demonstrated in iPad as it was actually produced and created a realistic UX. We then used iCAN 2.0 to conducted the second UXT and recruited IT members. One interesting findings was that the different UX presented by different simulating media triggered Children with Autism and their caregivers different ideas and questions about how to improve iCAN. Moreover, we invited two Children psychologists majoring in Autism to evaluate iCAN 2.0. They provided some professional suggestions about how to education properly.

The iCAN 3.0 was then implemented with the collaboration with IT members on an Android-enabled tablet device with a ten-inch display screen. After finishing, children with Autism, caregivers, children psychologists, and IT professionals evaluated this version. It was interesting to find that they still provided many feedbacks about the cons and pros of UX in iCAN. Finally, iCAN 4.0 was produced based on the suggestions on iCAN 3.0 and was sent out to be evaluated again. After in cooperating the suggestions from iCAN 4.0, we stop the cycles between UXD and UXT. Our finding was that the four cycles between UXD and UXT sharped the user experience of iCAN into a good conditions. Most of them were identified through different fidelity of prototypes and state holders of iCAN users.

IV. THE DIFFERENCES OF UX

To have a deeper understanding of the iCAN UX, we deployed iCAN over a four-week period onto eleven children with autism, age ranged from 5 to 16 years of age, diagnosed with autism from moderate to severe, and demonstrated verbal skills from low to none, and onto the caregivers of the children, consisted of eight parents and three special education instructors, aged from 26 to 60 years of age. All the participants had prior experience using traditional Picture Exchange Communication System (TPECS), and were asked to use iCAN two to five times a week. During the four-week deployment, each caregiver participant was interviewed about how they utilized iCAN by offering stories and interesting, surprising, and differences of using TPECS and iCAN.

The results showed significant reducing of the burden of producing picture and cards and the teaching burden, which have been published [13].

This paper presented the differences of UX according to ISO definition. According to the ISO definition user experience includes all the users' emotions, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use. The UX differences between TPECS and iCAN were showed in the followings

In terms of cognition, using TPECS did not help Kids make connection to real objects, while the real pictures of iCAN enabled kids make connection easily. In terms of emotion, TPECS hindered the search process ,while the categorization system of iCAN enabled kids to locate the needed pictures quickly and easily during the communication. This situaiton enabled kids to express them and prevented angry resulted from the situation when they cannot find the card they wanted. In terms of preferences, kids did not prefer the pictures made for them by their parents, while they preferred the cards took by themselves using iCAN.

In terms of perception, TPECS lacked of perceptual stimulus, while iCAN could record the sound of the object to provide hearing stimulus. In terms of physiology, the operation of TPECS could not increase the flexibility of kids' hands, while the operation of iCAN increased the flexibility of kids' hands by different gestures, such as long-pressing, sliding, pointing. In terms of mental situation, most kids felt bored often when using TPCES, while expressed heavily interest in using iCAN on tablet.

In terms of behavior, TPECS couldn't guild kids to waste hands before dinning, while the movie captured and played by iCAN helped kids to have the habit of washing hands. In terms of accomplishments, TPECS provided slow accomplishments, while iCAN provided some clear accomplishments during four weeks. Some kids could clearly express their needs verbally.

The results provided clear differences of using iCAN in improving their learning process. iCAN proved to be an useful, usable, even desirable orange technology. To conclude, this study reported an UX based design-through-researhc processe to establish Orange Technology. The results showed iCAN significantly improved user experience and reduced the burden of kids with Autism and their caregivers. This paper provided a great beginning to develop a series of assisting computational tools for kids with Autism. The results contributed in the establishment of design method of Orange Technology and the demonstration of how influential Oragne Technology could be for underpriviledged people.

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