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Developing user interface design application for children with autism

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Abstract

The usage of touchscreen-assistive technology in the 21st century seems very promising. There has been a rapid rise in interest regarding the use of touchscreen assistive technology as an intervention and interdisciplinary research field for children with autism. Inventing and designing a touchscreen-assistive application for children with autism is a delicate process as designing technologies for groups of individual with profiles other than one's own is always challenging where the life worlds and lived experience are far removed from the experience of typical individual. Participatory design process that has been conducted with children with autism earlier in the study has led towards the invention of touchscreen-assistive learning numeracy apps (TaLNA). The application is focusing on basic numeracy and calculation to support teaching and learning. User interface design has been used as a baseline in establishing the TaLNA apps. It is a complement from the traditional approaches such as call cards and cue cards which being applied at the touchscreen devices. The TaLNA apps is believe assist parents, teachers, and instructors to train and educate the children with autism while growing their engagement and interest in learning. It is a hope with the establishment of this application, they will be able to learn, memorize and recognize the numbers through the animated and interactive learning application. Thus, this research paper discusses the user interface design process of forming TaLNA in assisting the teaching of basic calculations to children with autism.

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Keywords: Autism, Touchscreen Apps, User Interface, Numeracy

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1. Introduction

Autism is a developmental delay in an individual and it occurs as a lifelong condition. It causes delays and problems in many different skills that are necessary for a typical individual to carry out daily living tasks in becoming self-reliance. Children with autism have different cognitive abilities than typical children as their condition deficit them in terms of social skill, communication skill and limited imagination (Hasnah Toran, 2013). However, using certain established method, the education of children with autism is possible and promising in promoting future independence and self-determination in them. Applied behavior analysis (ABA), for example, is said to be the most effective method in teaching most children with autism. Researches have also introduced structured teaching method as being recommended in Treatment and Education of Autistic and related Communication-handicapped Children (TEACCH) program (Rao & Gagie, 2006). It has been established that children with autism learn better through visual and interactive approach whether through traditional method or digital method. Picture exchange communication system (PECS) and TEACCH program is one of the examples of the successful method of teaching where visual learning plays a big part in it (Rao & Gagie, 2006). Nowadays, these methods were ventured by researchers from various fields to be embedded into digital-based medium such as computers and touchscreen mobile technologies.

Digital method may not exist to completely replace the traditional method but to complement the existing method by providing the users with ease of use. Technology has advanced so much that not only it has become a necessary tool in everyday basis, but its use has also been made more significant by assisting people with special needs. Computer instruction is also reported to be widely preferred among individuals with autism that they would rather use computer to playing with tangible toys (Munoz, Barcelos, Noel, & Kreisel, 2012) (Kamaruzaman, Azahari, & Anwar, 2012). Besides, it has also been reported that a lot of children with autism were immersed with visually based media and have more tendency to learn through this kind of media such as computer (Nally, Houlton, & Ralph, 2000) (Kamaruzaman, Rahman, Abdullah, & Anwar, 2013) (Kamaruzaman & Azahari, 2014). In complementing the traditional method by supporting the process of teaching and learning for children with autism, this paper is establishing the design process of TaLNA, an application to assist the teaching of children with autism basic numeracy and calculation, following the design principle and established guidelines in designing for children with special need, mainly, autism. This application is to be used by parents and special educators to teach basic numeracy and calculation skills to children with autism. TaLNA is an application that complements the traditional method such as cue cards and flash cards that are implemented over a touchscreen device. Designed based on the concept of ABA intervention, this application compels positive fortifications for every correct response. This application is expected to keep the children engaged through its colourful, animated, and interactive learning. It is built as a platform for parents, educators, and caregivers to help the children to learn, discover as well as developing their skill to achieve self-determination. Each scene will give the children the possibility to: 1) Learn and discover the name of each numbers, 2) Practice writing of each numbers by tracing the image dots, and 3) Learn to count and solve the addition arithmetic problems. Hence, this paper presents an overview of the process in designing this application to suit the users' need.

2. Related Work

Prior to the rapid development of digital media, many researches were made regarding human-computer interaction (HCI) for children with autism. Computer software and mobile applications were well developed by researchers in order to assist the learning and development process of children with autism (Chien et al., 2015) (Hourcade, Bullock-Rest, & Hansen, 2012) (Pavlov, 2014). These researches agree that user interface (UI) design is an important part in HCI as it may indicate the successfulness of software or application that was developed (Pavlov, 2014). A good UI design, as it permits the user to carry out tasks, encourages an easy, natural, and engaging interaction between a user and a system. Plus, systems that are easy to use and easy to understand require less training as well as leading to a higher productivity and user satisfaction. Despite being a major role in the usability and accessibility of a system, UI design for users with autism is another challenge. This is due to the differences in the life worlds and lived experiences of children with disabilities from the experiences of typical

designers or researchers (Frauenberger, Good, & Alcorn, 2012). Also, it has long been established that visual support is one of the effective tools to enable children with autism to communicate and to learn with more ease. Children with autism were often referred to as visual thinkers (Frauenberger et al., 2012). A good number of researchers have found that children with autism reacts more through visual than other sensory (Hayes et al., 2010; McKone et al., 2010; Milley & Machalicek, 2012). Children with autism may increase their communication ability through visuals as well as slowly decreasing their reliance on the promptings from adults. Additionally, many researches has found that interactive visual in mobile technology were useful to support children with autism learning. A very well-known merit of mobile technology is its use for self-instruction (Ayres, Mechling, & Sansosti, 2013). With self-instruction, children with autism may obtain a higher level of self-determination and this will make it possible for them to manage with their personal tasks. Tablets, for example, have been successfully used as a Computer Assisted Instruction (CAI) device and as an Augmentative Alternative Communication (AAC) tool with the appropriate software, making it possible for autistic people with severe speech impairment to communicate their needs (Mejía-Figueroa & Juárez-Ramírez, 2013) (Torii, Ohtani, Niwa, Yamamoto, & Ishii, 2012) (Kamaruzaman & Azahari, 2014). There are also applications that adopt conventional method or module so it can be used digitally. Developing software applications like YoDigo is one of many examples that had adopt the conventional method into digital application. YoDigo an application that adopted PECS to help with the communication of a speech impaired autistic user (Mejía-Figueroa & Juárez-Ramírez, 2013).

In creating software applications for users with autism, it is crucial to follow certain guidelines and principles that have been established. User interfaces have strong relationship to its demographic of target users and users with autism are target groups that are out of the usual as they may have different worldview than the researchers and designers. A good user interface designer must be able to attempt to reduce the complexity of software and create a domain, which makes it easy, efficient and enjoyable to work with (Darejeh & Singh, 2013). Based on the principle of user-centered design, there is no proper design for all groups of users (Darejeh & Singh, 2013), which makes it more important that a software application should be developed, based on target users' cognitive ability. Thus, based on the established design principle and guidelines, TaLNA is designed to meet the need children with autism. Every aspect that may contribute to the system's usability and accessibility for the use of the end user is taken into considerations in designing the UI of this application.

3. Design Process

In designing TaLNA, several processes have taken place based on established design guideline in designing a task-centered UI. These tasks were chosen early in the design effort, which then is used to raise issues concerning the design so design decisions may be made as well as to evaluate the design as it is being developed (Lewis & Rieman, 1993) (Abras, Maloney-Krichmar, & Preece, 2004). The steps in the task-centered design process has been adapted in designing TaLNA and modified as necessary.

3.1. Task User Analysis

Before beginning any design, researchers and designers must figure out who is going to use the system. In this step, the users' background knowledge helped the designer to answer questions regarding the elements that should be included in the design considering the users' ability. Defining the user may help in deciding the task suitable for the system to be used by the users, in this case, high functioning children diagnosed with autism.

3.2. Choose Representative Tasks

When the users' criteria were definite and clear, the tasks for the system could then be chosen. In this step, designers and researchers sat down and discussed how the flow of the system should be. From the discussion, a flow chart describing the flow of the application was produced as a guideline in developing the application. Tasks were designed based on the Numeracy Module 1 syllabus that has been established in teaching numeracy for children

with autism that was developed by Autism Lab of Faculty of Education, Universiti Kebangsaan Malaysia (UKM). Based on the syllabus, the children will learn the number from 1 to 5 first before they learn 6 to 10. The children will also learn how to write the numbers through a task, which require them to connect the dots that form the number they are learning. Afterwards, they will be tested to match the number. They will also learn to do simple addition calculations. The flow of the application is as indicated in Figure 1.

3.3. Find Existing Interfaces

Before the UI is properly designed, existing interfaces that work for users were made as reference to build ideas into the systems as much practically as possible. The existing interfaces were selected based on the most similar situation as possible before it is made as reference to build the system. This step is necessary because the answer to a good UI depends on how often the users will be running the system compared to how often they will be running systems that they already know (Lewis & Rieman, 1993).

3.4. Rough Out the Design

The rough description of the design is then put on paper. In this stage, the design team made an in-depth discussion on the features the system should have before a prototype may actually be built so it may be tested out to the end users. Please refer figure 1.

3.5. Analyze User Interaction

Before the mock-up or prototype can be made, the designers first analyze how the users might interact with the interface that has been roughed out in performing specific tasks. In this stage, designers try to spot places in the design where the users might make mistakes.

3.6. Create Prototype

Mock-up or prototype is necessary so hidden misunderstanding may be revealed. The prototype, however, did not nor did it need to implement the entire design. This prototype was made only to find fault of the system and find ways in improving it in terms of functionality and usability.

3.7. Test Design to Users

Afterwards the built prototype was tested to the users to bridge the gap that might still exist. This stage opens the door for designers for further improvement of the system to suit children with autism of the chosen demographic. Designers were then able to analyze the list of features that may need to be improved so it will be more usable and accessible for the children considering their cognitive ability.

3.8. Iterate

There are always some problems with the design after it has been tested to the users. Based on the test results, the interface was revised and will be tested again. Re-examination may occur several times before the specific usability objectives are defined.

3.9. Build the Design

Final step in the development of TaLNA before it may be commercialized is building the end product. After every problems and errors are fixed and improved, only then the final design may be built.

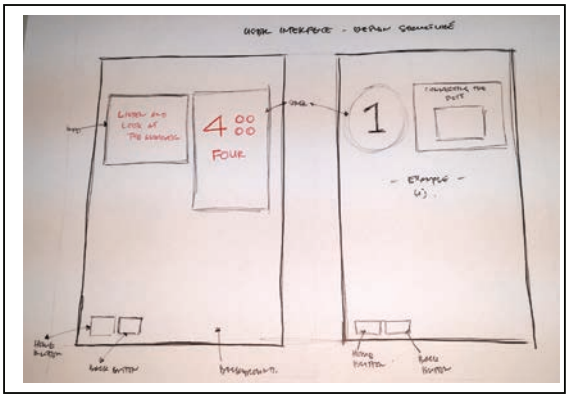

Fig. 1. User Interface Design Ideation

4. Graphic Design Principle

In designing TaLNA, the graphic design involves five important principles (Lewis & Rieman, 1993) in designing a user interface. The first principle is the *'Clustering Principle'*. Clustering principles is organizing the screen into visually separate blocks of similar controls (Lewis & Rieman, 1993). This principle is important to help users to search for the command they needed and by grouping commands together helps the user to acquire a conceptual organization of the system. The second graphic design principle is the *'Visibility Reflects Usefulness Principles'*. This principle makes frequently used controls visible for the users to access and hide the less frequent controls (Lewis & Rieman, 1993). This will reduce clutter on the screen that might affect its efficiency. Next is the *'Intelligent Consistency Principle'*, which encourages using similar screen for similar functions. This will be useful as it lets designers to concentrate effort to design just a few attractive, workable screens, then modify slightly for use in other parts of the application (Lewis & Rieman, 1993).

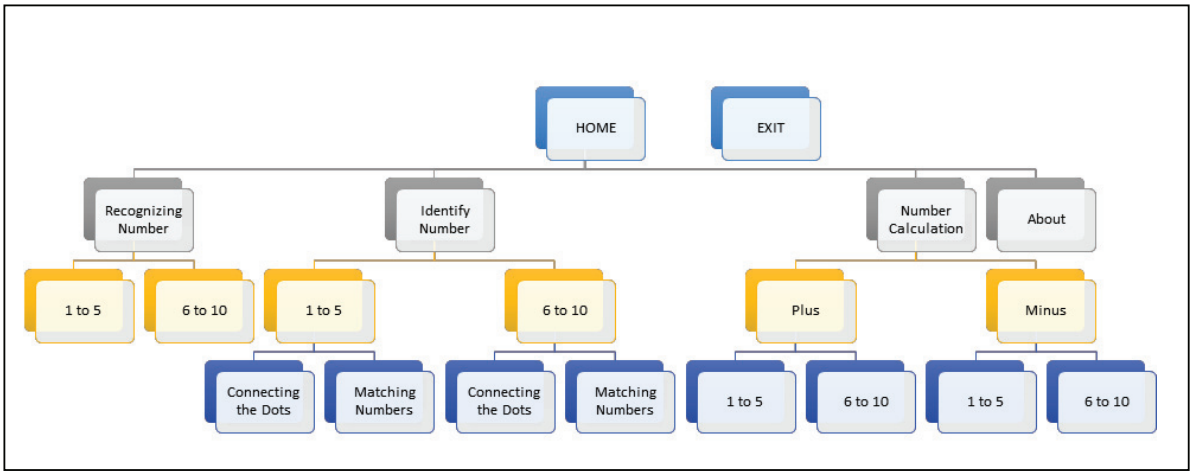

Fig. 2. TaLNA design flow.

The fourth principle is the *'Colour as a Supplement Principle'*. Colour should not be relied to carry information but it has to be used as a supplementary to emphasize information through other means. Last but not least is the *'Reduced Clutter Principle'*, which is also very important. Too many inputs on the screen may cause confusion to the users. Thus, a design needs to be as simple as possible without leaving out attractive touch on it. In addition, UI design for TaLNA is designed according to established guidelines in designing UI for children with

autism spectrum disorder. The guiding principles of the methodology consist of rules established for document preparation for people with learning disability. The rules applied are as follows (Pavlov, 2014):

1. Each idea needs both words and pictures, as both elements are equally important.
2. Pictures and words go next to each other, as this helps more people to understand the information.
3. Make sure that it is clear which picture support which bits of text.
4. Pictures must be easy to understand.
5. Pictures should go on the left.
6. Pictures can be drawings, photographs or other images.
7. Make sure that pictures are as big as possible.
8. Words must be easy to understand.
9. If difficult words are used, say what they mean in easy words.
10. Words go on the right.
11. Words must be written clearly.
12. Words must be big.
13. Each sentence should be as short as possible, not more than 15 words.
14. Each document must be short.

Additional recommendations based on the same rule of principles were also taken into considerations such as keeping sentence together in one page, do not filling the page with too much information, illustrations should be in sharp focus, never use inverted printing as well as never use roman numerals (Pavlov, 2014). These principles are crucial in designing interfaces for children with autism. Thus, inspired by these principles of design, TaLNA designs its UI suits the requirement for the use of children with autism, suiting their cognitive ability and needs.

5. TaLNA User Interface Design

Based on the established principles guidelines, TaLNA was designed suitable for young children with autism to learn numeracy and basic calculation. The application will begin at the home page where the user will be able to choose the desired task.

Fig.3. Recognising Number interface

The first task in TaLNA will be ‘Recognizing Number’ (refer to Figure 2). In this stage, the user will have the choice to learn the numerical system either from ‘1 to 5’ or ‘6 to 10’. For a child who is just beginning to learn the numerical system, they should choose option ‘1 to 5’ to master first before they were able to move on to ‘6 to 10’. Children will learn to recognize each number, which will be provided with visual, word and voice over. Figure 3 shows the interface design for Recognizing Number. Once user enters the stage, the number image will appear along with a voice over. The next number will appear when the user hit the ‘next’ button. The numbers will appear in ascending order unless the user hits the ‘back’ button. Following the design principle, the page is kept simple and avoiding clutter. The foreground colour is contrasted from the background while both words and images are visibly

big and clear.

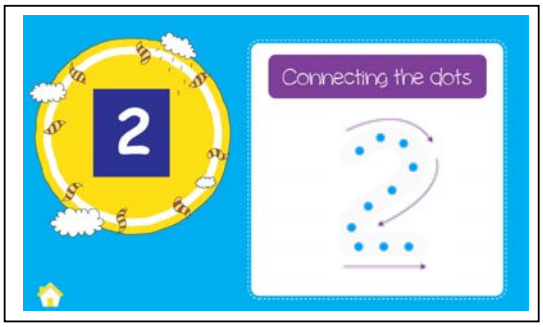

Fig.4. Connecting the dot page

The second task is Identifying Number. Again, user will require choosing options either ‘1 to 5’ or ‘6 to 10’. In each of the options, they will do activities called ‘Connecting the Dots’ and ‘Matching Number’ for each number. Figure 4 shows the page for connecting the Dots. The user will have to connect the dots to form the number. The arrow indicates where the user should start connecting the dots and where it should end. Example of the number structure is given on the left for the user’s reference.

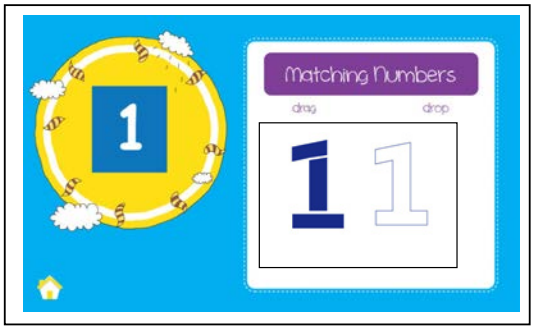

Fig.5. Matching Number page

The Matching Number’s page is as shown in Figure 5. Each number is divided to a few pieces. The user is required to drag and drop each piece of the number to the empty frame on the right as if completing a puzzle. The first level is easier where every piece is arranged in order. The higher levels will be more difficult where the pieces are more scattered than the previous levels. The interface designs in the activity pages were not much different except for the content of the activity. This is because the pages serve the same function, thus, to prevent confusion, the same layout is used.

6. Conclusions

The application described in this paper was designed to assist the teaching and learning of numeracy and basic calculation for high children with autism through touchscreen mobile application. The design principle and guidelines in designing UI for applications that suited the needs of children with autism is extremely important. A good UI considers the demographics’ cognitive ability. Thus, defining the user model is a crucial process at the beginning phase in order to decide the system’s task and interface design in the later phase. Previous preliminary phase resulted in good feedback and more improvements could be made in terms of the design flow and the UI design. It must be noted that in designing UI for children with autism is not limited to only the guidelines and

principles used in this paper. There may be other useful guidelines that are more suitable depending on the demographic of the end users.

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