

# iCanLearn: A Mobile Application for Creating Flashcards and Social Stories™ for Children with Autism

**Abstract**— This paper describes the design, implementation and evaluation of the iCanLearn mobile flashcard application (app) that can also be used for creating social stories for children with Autism Spectrum Disorders (ASDs). The app allows users to create personalized content using text, pictures and audio on their mobile devices (smartphones and tablets). Users of this application software can also share the content by connecting their devices over wi-fi. An evaluation of the app from both the perspective of children with ASD and their caregivers suggests that the app is easy to use.

**Keywords**—*computer-mediated communication; user-centered design; design methods; mobile application; assistive technology.*

## I. INTRODUCTION

The prevalence of autism spectrum disorders (ASDs) has increased to an estimated 1% of the US population [1], presenting new teaching and learning challenges for parents, teachers and these children. An additional challenge is the great variability in the level of functioning of children with ASD, who present with mild to severe communication, social interaction and behavioral problems [2]. However, mobile computing is a flexible and popular medium for teaching children with ASD [3-5] and therefore holds promise for the development of innovative interventions to address the wide range of learning abilities for this growing population of children.

It is believed that with effective treatment and intervention, many children with ASD will improve their level of social, communication and behavioral functioning and subsequently their quality of life [4, 6]. One technique that is effective for teaching children with ASD is breaking down an activity into steps, and replacing words with pictures [4]. Another technique, called Social Stories™, uses a series of pictures with words representing the steps of a routine (e.g. getting a hair cut) along with scripting of expectations for the child (e.g. “I might have to wait”). The stories help the child with ASD understand how someone else might be feeling, and how they can respond appropriately [7, 8]. Literature shows that the stories improve the child with ASD’s understanding of social expectations for behavior in multiple studies across a

variety of settings [9-13]. Both these methods are thought to improve the child’s expectations of routines and behaviors expected of them during the routines.

We developed a mobile flashcard application - iCanLearn - to help parents and teachers of children with ASD develop and edit social stories. This software allows the creation and review of individualized learning content adaptable to the child’s level of functioning, on a mobile device that has been shown to be effective with children with ASD.

The iCanLearn app allows the user to create personalized content with text, pictures, and audio and connect multiple devices together in a teacher-learner relationship. We evaluated the app for ease of use, which is recommended for assistive technology [14] and report on the findings of the evaluation in this paper.

### A. Contributions of this paper

iCanLearn, is a mobile application developed to facilitate transfer of content (pictures, words and audio) between two mobile devices. The content helps children learn skills related to activities of daily living. The contributions of this research work are as follows:

- We encourage an individualized learning approach by making it easy to create and edit flashcards based on the specific needs of a child.
- We demonstrate a technique for connecting multiple devices in a teacher-learner relationship.
- We provide an engaging experience for children with ASD by using pictures, text and audio.

In the following section, we look at the related works in the areas of touchscreen applications, gaming and flashcards. We also review some of the learning applications available in the market. We then talk about the motivation behind this project and how the need for an app like iCanLearn was identified. We provide details about our application iCanLearn, in terms of its features, design and the scenarios it can be used in. In the next section, we evaluate our system in

terms of goals met. Finally, we conclude our work with details about future work.

## II. RELATED WORK

With the advancement in mobile technologies, the learning environment is no longer restricted to classrooms and paper-based materials. Mobile devices provide a flexible way of learning where the content, timing, and location of a learning schedule can be arranged according to user's preference [15, 16]. A mobile device is usually equipped with camera, microphone, and speaker, which can aid to content designing. With these features, mobile technology has led to the growth in development of educational software. This software, in the form of application software or mobile game, can be designed according to the specific needs of a user or customer.

To date, many mobile applications have focused on learning how to read and write, which can be difficult for children with ASD (e.g. iWriteWords, Sight Words, Rocket Speller, etc. [17]). In one app, writing is facilitated by following dots on a screen. In another app, pronunciation of words is possible by making use of audio feature that also help retain the child's attention. Similar to having an audio feature, showing a picture of the word being spelled is also an effective way to learn a word, its meaning and its physical appearance. All these features help increase the effectiveness of assistive technology for facilitating learning.

Educational computer games are also helpful while working with children with ASD [18, 19]. TouchStory™, is an educational computer game designed to help children with ASD improve relational skills by working to strengthen their reading comprehension [20]. This game was developed for use with a touch screen monitor in case the child with ASD has trouble using a mouse and keyboard. The game is engaging with attractive graphics and sounds. As such it is entertaining and may hold the child's attention for extended periods of time, which may improve the child's retention of the material [21]. Heightened anxiety has been associated with disrupted recall of information, and poor attention [22]. Adding gaming features (audio and visual) to the iCanLearn Flashcard app may improve the child with ASD's ability to learn the material on the cards in a similar way to gaming.

Flashcards are widely used as an instruction medium for teaching specific skills for example, reading, spelling, and phonetics. Moreover, flashcards have been shown to be an effective method for teaching children with learning disabilities, such as ASD [23-26]. Flashcards are used to teach a wide variety of topics, from simple mathematics to historical dates, or from sight words to scientific formulas. The flashcard-based system and mobile technology can be combined, in order to get the maximum benefits of these two learning means. There are hundreds of flashcard apps for iOS and Android [27]; which differ from one another in several ways. Some of the available options are based upon: (1) the availability of pre-made cards which may or may not have picture and audio options along with text, (2) sharing of the cards via email or import/export feature, and (3) the algorithm used for spaced recognition systems [28]. Some of these

flashcard apps were specifically designed for Applied Behavior Analysis (ABA), which helps with improving social behaviors in an individual [29]. These apps usually have ready-made slides that contain pictures, sound, and text. The typical learning session using one of these apps follows this pattern: the parent/caregiver of the child launches the flashcard app on a mobile device. They navigate through the menus to get the flashcards queued up for the child. The parent/caregiver gives the mobile device to the child to go through the flashcards. However, depending on the special needs of the child, the parent/caregiver might need to sit with the child to help them navigate through the deck of flashcards and make sure the child doesn't accidentally get out of the app or go back to a menu within the app, etc. Thus, the weakness of this type of app is the inability of the child to be self-sufficient using the app, which is especially important for children with ASD.

A lot of ABA flashcard apps available today are aimed specifically at typical symptoms of ASD, for example trouble with recognizing emotions. One of these apps, Emotions by Alligator Apps, does just that. It comes preloaded with flashcards that include text, pictures, and sounds to help children with ASD to identify, understand, and respond appropriately to emotions [17]. Therefore, the app doesn't allow customization of content.

Social Stories [17] is an ABA app that allows people to create and edit flashcards for the purpose of illustrating and telling Social Stories™. The flashcards are organized according to which social story they belong and consist of text and pictures. There is no support for audio. There is also no camera support; pictures must be imported from the library. This app could be very helpful if applied in therapy for children with autism, but has the weakness of not allowing custom individualized content.

TABLE I. COMPARISON OF FEATURES IN MOBILE SOFTWARE

Mobile Software	Custom Content	Control Remotely	Audio	Pictures
Where's my Water?	✗	✗	✓	✓
Shape Builder	✗	✗	✓	✓
iWriteWords	✗	✗	✓	✓
Little Speller Site Words	✗	✗	✓	✓
Rocket Speller	✗	✗	✓	✓
Emotions	✓	✗	✓	✓
Actions	✗	✗	✓	✓
Social Stories	✓	✗	✗	✓

We found that many of these apps engage children with audio and visual elements. Some of them allowed for individualistic learning approaches by allowing for the creation of custom content. However, none of them allowed for content to be shared between two devices in real time. Table I shows the comparisons of the mobile software we reviewed.

### III. MOTIVATION

Reviewing other apps helped us identify the key features required to develop an effective assistive technology. The following scenarios are helpful in understanding the need for such a tool.

#### A. Scenario 1

Ms. Susan is a teacher who works with children who have learning disabilities. She creates flashcards for the concepts and topics that each student is working on. This works well for some students, however, Zack, one of her students has a very low tolerance for personal contact. He engages in disruptive behaviors when the teacher, or another student, gets too close to him when reviewing the flash cards. The teacher also notices that many of the drawings on the flashcards do not seem to make sense to this boy. She experiments with cutting out pictures from magazines, downloading images off websites, and taking pictures of things, printing them out, and then gluing them to the flashcards. This seems to work a lot better, especially the pictures she takes herself around the school, perhaps because the boy is more familiar with the objects, people, and locations in them. As can be realized this process of creating flashcards is very time consuming. In teaching the children about vehicles and transportation, she has found that another boy with ASD is unusually fascinated with certain flashcards, especially ones that have trains on them. He likes to hold these cards in his hands and look at them for long periods of time. Sometimes, when she tries to take them away, or get him to flip to the next card, he screams and yells. She tries holding the cards herself while she reviews them with him, but he becomes disengaged when she doesn't let him hold and flip through the cards himself.

What could be done to improve this teacher's situation? She needs an easy way to create and revise flashcards. She would also appreciate a way to review them with her students without having to have too much personal contact with them. In the case of the second boy, she would like to allow him to hold the flashcards, while she maintains control over when to switch to the next one.

#### B. Scenario 2

Jennifer's parents have been having difficulties getting her to cooperate in the mornings while waking her up and getting her ready for school. They create a social story that illustrates the situation with appropriate behaviors, but she isn't responding well to it. Her mother thinks that the sentences might be difficult for her to understand because they are too long. They try using actions with the words, such as yawning when they talk about getting out of bed. This doesn't seem to help, so they try creating flashcards with pictures downloaded off the Internet and a few from their family photos. The girl

seems more engaged when the pictures are there to illustrate what her parents are saying. She's especially responsive to the pictures with her family and home. Her parents keep going through the social story with her, and eventually her behavior starts improving.

What are some of the things her parents discovered that contributed to this success? The social story and flashcards were created based on her individual needs. The use of pictures to illustrate the social story helped the girl understand what she was hearing. The use of pictures taken of her home and family were familiar to her, making her feel more comfortable, so she was more engaged. Research shows that social stories are an effective tool for teaching children with autism appropriate behaviors [30]. It makes sense that children with autism would respond to flashcards with pictures of familiar things better than pictures of things that are new to them [31].

### IV. iCANLEARN – A MOBILE APPLICATION

#### A. Overview

iCanLearn is a flashcard educational app that allows you to create your own flash cards with text, pictures, and audio. While it's an effective learning tool on a single device, what makes iCanLearn unique is the ability to connect multiple devices in a teacher-learner relationship over a non-enterprise Wi-Fi network. This allows the teacher device to display its flashcards on the learner devices. This app is helpful for anyone at any age, but it is designed specifically with children in mind. It is especially useful for reaching children with ASD or other impairments in social functioning. It provides a medium for them to learn without first requiring them to overcome the social obstacle.

The workflow of the app is fairly straightforward. A user selects their role: teacher or learner. Then they select whether or not they want to connect to another device or just view flashcards on the device they are holding. Finally they select a category of slides and the slides they wish to view. User scenarios will be discussed later for illustration.

#### B. Features and Design

iCanLearn is a flashcard app that offers the key features of text, pictures, audio, and connecting two devices in a teacher-learner relationship. No other app was located that connects two or more devices in a teacher-learner relationship. Some of the more common features across flashcard apps are implemented in unique ways that make iCanLearn stand out. These features and the process of the development of the app are described below.

##### 1) Appearance

The design theme for iCanLearn is simple and uncluttered. A sentence case with sans serif font was selected for ease of reading.

##### 2) Navigation

Navigating the transition from screen to screen is accomplished by a visual flip with 3-D animation. There is one exception to this, when you are viewing slides and you

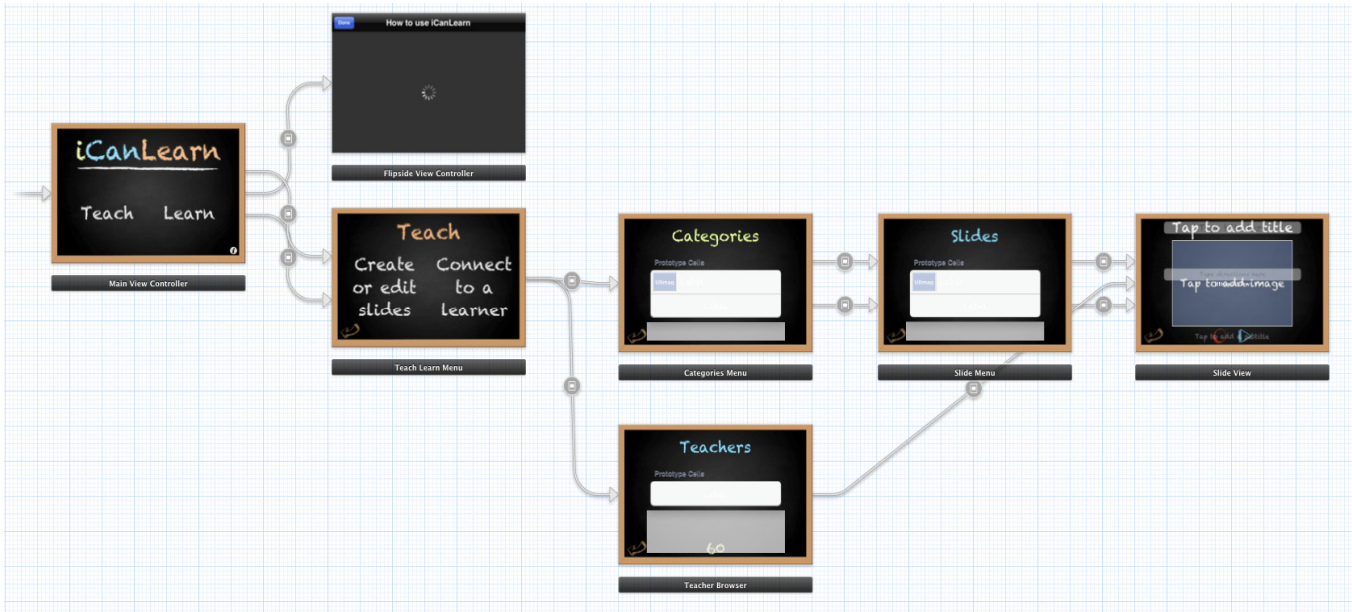


Fig. 1. Storyboard of iCanLearn in Xcode

swipe your finger to go to the next or previous slide, instead of a 3-D flip here, the decision was made to have the chalkboard slide off the screen in the direction of the swipe. A new one then slides in from the opposite side of the screen to take its place. This was done because it was thought that it would feel more natural to the user and it would visually communicate to them that they are looking at a different slide instead of the back of the slide they were previously looking at. Figure 1 shows the screenshot of the storyboard of iCanLearn app in Xcode (the IDE used for creating iCanLearn). The storyboard feature of Xcode was helpful in laying out the screens and managing transitions between them.

### 3) Textual Information

Text is essential in a flashcard app. It's probably the one thing that all flashcard apps have in common. The first version of the app had two text fields: a title and a subtitle. The idea was that when you create the slides, you would type the title of the slide, and then type some directions or hints in the subtitle field. After some testing, however we removed the subtitle text field because it rarely got used.

### 4) Images

Implementing pictures was difficult due to trouble with the storage and retrieval of the images. For example, storing the

images in a Core Data, SQLite database would have a negative effect on the performance of the app, so instead, they are written to disk and a file path is stored as a string in Core Data. Figure 2 shows the Core Data Model of iCanLearn.

Giving users the ability to take their own pictures right within the app as well as accessing stored photos on their device that they had already taken or downloaded from the Internet is essential. The images had to be resized. If they were not, they looked pixelated when they were displayed on the screen. Another challenge to overcome was that the image view components displaying the images in the flashcards are sized differently depending on the device. If it's an iPad, it's a lot bigger than on iPhone or iPod touch. In the earlier versions of iCanLearn, images were resized before they were written to disk. The rationale was that it would use less hard drive space and might make the app perform faster. This would be especially noticeable when transferring flashcards to another device.

Later we realized that the full image needed to be stored and then resized just before being displayed. The driving force behind this decision was that it's necessary for devices to send images to each other, and not every device has the same screen size. If you passed a picture from an iPhone to an iPad, it wouldn't look right because it had been compressed and resized for the dimensions of the iPhone screen. Furthermore, some devices have better cameras than others and some devices have retina displays with a much higher density of pixels per square inch. Therefore, it simplified things to store the image in its original state, and let each device resize it appropriately for its screen. Figure 3 shows a slide created and displayed on an iPhone 4s with a picture taken with its camera. It also shows that same slide being displayed on an iPad 2 connected to the iPhone 4s in a teacher-learner relationship.

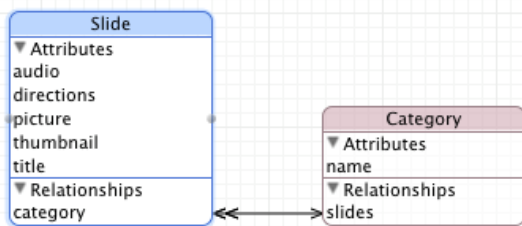


Fig. 2. Core data model of iCanLearn



Fig. 3. Picture display on two different sized-devices (iPad and iPhone)

### 5) Audio

Recording and storing audio presented another set of choices and challenges. As with the images, we elected to store the audio on the device's hard drive and store the file path as a string in Core Data. This makes for much better performance when querying the database to populate the slides menu or category menu tables.

Some choices had to be made when it came to the quality of the audio recordings. Most of the audio being recorded was going to be spoken by users and played back by the tiny speakers of the mobile devices, so quality was not as important as file size and app performance. Therefore, a single channel, low quality recording with a sample rate of 44.1 kHz was chosen.

### 6) Playback Control

The controls needed to be simple and easy to use. Buttons with words on them are a poor design choice for a number of reasons. They can cause problems when translating an app into another language. It slows down the user when they are recording or playing audio, because they have to stop to read the label on the button to make sure they are tapping on the correct one. Hence, the standard playback symbols were chosen: triangle for play, square for stop, and circle for record. These can be found on many audio devices and in many audio software programs. In order to continue a minimalistic approach, the app only displays two buttons at a time, swapping them out as needed with other controls. For example, when you tap the record button, it turns into a stop button, and when you tap it again to stop the recording, it turns back into a record button.

The main feature that differentiates iCanLearn from other flashcard apps is its slide sharing capabilities. Some flashcard apps let you share cards. That is, you can transfer them to another device, upload or download them via a service like Quizlet, Study Stack, or Flashcard Exchange [27]. This is a very nice feature; however, the user scenario for these flashcard apps is still a single-device, solo experience.

With iCanLearn, you can connect two or more devices over a Wi-Fi network in a teacher-learner relationship. This means you can give children devices running iCanLearn in

learner mode and send them slides from your device running in teacher mode to be displayed on their screen. This feature seems to be missing from the other flashcard apps. It is helpful for children with ASD as they may become frustrated when their routine is interrupted.

Another idea kept in mind when developing this app was the possibility of it being used in a classroom setting. iCanLearn is quite versatile. Envision a teacher creating flashcards for certain topics they teach on and using iCanLearn as they present to their class. It might help to encourage attentiveness in the children. It might even prove to increase knowledge transfer to the students as well as bolster their recall because the presentation would address more sensory preferences and learning styles of the children. This could be effective in both a regular classroom environment as well as in special education.

In the initial release of iCanLearn, the feature of importing and exporting cards was not incorporated. However, it could be an incredibly helpful feature. For example, two parents would be able to share their slides with each other, so their child would have the same learning experience no matter which parent is working with them.

There are future plans to explore different possibilities. One option would be to simply share and store the flashcards over the Wi-Fi network between devices instead of just displaying them. Another would be to set up a cloud service, so that people all over the world could share cards specifically made for iCanLearn. A third option would be to share slides via an existing service such as Quizlet, Study Stack, or Flashcard Exchange. User input will be taken into consideration while deciding these options.

There are already a number of apps that have ready-made cards that address common symptoms of ASD, such as recognizing and responding correctly to emotions. This seems to limit the user's thinking about how the app can be used. For this reason, iCanLearn does not ship with ready-made cards. Instead, users are encouraged to create their own unique content, tailored to the specific needs of the child or children.

While this may take a little extra setup time for the user, in the long run it will result in iCanLearn becoming a more effective learning tool. The flashcards will have familiar images on them should the parent or teacher choose to take their own photos for the cards instead of downloading them from the Internet. The audio in the flashcards will be of the voices of the child's parents or teacher. Familiarity will help children learn faster. It will help them feel more comfortable. Each flashcard will be created with a child's specific learning needs in mind.

Some flashcard apps apply tracking, where you can flag cards to hide in a stack. This is useful if you are studying on your own. Tracking was not integrated into iCanLearn because it is meant to be used in the teacher-learner scenario. In that setting, a teacher can decide which slides the student should and shouldn't see.

Some flashcard apps provide a way to sync cards with a website or a desktop version of the program. For the sake of time with this project, we have not implemented something

like that. However, it could be quite useful, especially in a classroom setting. Many schools already have computers that would be able to run a web and/or desktop version of iCanLearn. It is doubtful that many of them have invested in mobile devices.

### C. User-Scenarios

In this section, the discussion will focus on three different user scenarios of iCanLearn in order to illustrate how the app functions. First from the teacher's perspective, then from the learner's perspective, and finally, the teacher-learner relationship will be addressed.

#### 1) *Creating and Editing Slides as a Teacher*

Creating and editing slides is the first thing users will do after downloading the app. The outline of that process is as follows:

1. Select "Teach" from main menu
2. Select "Create or edit slides" from teach menu
3. Select or add a category
4. Select or add a slide
5. Edit slide by tapping on any of the elements

#### 2) *Viewing Slides as a Learner*

Although the most powerful way to use iCanLearn is by connecting two or more devices in a teacher-learner relationship, it is useful as a standalone application. Below is an outline of the steps a user would take in order to view slides as a learner.

1. Select "Learn" from main menu
2. Select "View slides" from the learn menu
3. Select a category
4. Select a slide
5. View slides (swipe left and right to view next/previous slide), press the blue play button at the bottom of the screen to hear audio

#### 3) *Connecting Two Devices in a Teacher-Learner Relationship*

iCanLearn is at its best as an educational tool when used in the teacher-learner scenario. Below are the steps taken to connect two devices:

1. Ensure the devices are connected to a Wi-Fi network
2. On the teacher device (device that has the slides you wish to share):
  - a. Select "Teach"
  - b. Select "Connect to a learner"
3. On the other device(s):
  - a. Select "Learn"
  - b. Select "Connect to a teacher"
  - c. Select the device that you set up as a teacher

4. On the teacher device:
  - a. Select a category
  - b. Select a slide

Any changes made to the slide will be updated on the learner device.

The whole process is fairly simple to follow - making it a convenient tool for children and their caregivers.

### D. Using iCanLearn for Social Stories

iCanLearn can be used to tell and illustrate social stories. Think back to the scenario in the motivation chapter of this document about the parents of a girl with ASD who used a social story to gain her cooperation for her morning routine. iCanLearn could help other parents and teachers. They could create a category in the app, called Social Story where they could develop flashcards in that category with pictures, text, and audio that help tell and illustrate desired routine as a Social Story.

iCanLearn and Social Stories work well together. Social Stories delivered through and/or illustrated by iCanLearn are more effective than just reading them out loud. It is believed that iCanLearn will be a more effective educational tool for children with ASD if people use it to tell and illustrate social stories. The content would be based on the individual needs of the child for a personalized approach. There can be auditory as well as visual stimulation to accommodate multiple learning styles.

## V. EVALUATION

The aims of the evaluation of the app were to assess (1) the feasibility and usability of this app in terms of its features and design considerations and (2) the changes in the level of anxiety experienced by parents or primary caregivers of children with ASD before and after using the app.

### A. Measures

Since parenting a child with ASD can be demanding and comes with its unique anxiety producing stresses [32], using a new technology can be overwhelming for parents. We wanted to see if using the 'iCanLearn' app has any adverse effects on the anxiety being experienced by parents or not. For examining the changes in anxiety experienced by individuals, we used the six-item short form of the Spielberg State-Trait Anxiety Inventory (STAI) [33]. This six-item form is a self-rating scale and has been validated for providing similar scores to those obtained using the full 20-item STAI. It has satisfactory reliability and is useful in cases of time constraint. The six-items include both anxiety-present and anxiety-absent items, and were rated on a four-point Likert-type scale.

To assess the usability of 'iCanLearn' app, we created a web-based survey tool. This survey has 16 questions related to user experience (see Table II) and 8 questions on that collected demographic information to describe the participants.

TABLE II. USER EXPERIENCE QUESTIONNAIRE FROM THE EVALUATION STUDY

		Options (n*)				
1	Which of the following devices do you use on a regular basis?	iPhone (2)	iPad (1)	Both (2)		
2	For how long have you been using an iPhone?	3 months, 1 yr 8 months, 3 yr 2 months, 2 yrs				
3	For how long have you been using an iPad?	1 year, 1 yr 6 months, 6 months				
4	How would you rate your comfort level with downloading, installing and using an application on your iPhone/iPad?	Excellent (0)	Very Good (3)	Good (1)	Fair (1)	Poor (0) Very Poor (0)
5	Do you think that iCanLearn app is easy to use?	Strongly Agree (3)	Agree (2)	Disagree (0)	Strongly Disagree (0)	
6	Do you feel that users of iCanLearn should be provided with an in-person demonstration on how to use this app (iCanLearn)?	Strongly Agree (0)	Agree (0)	Disagree (3)	Strongly Disagree (2)	
7	Which of the following features of iCanLearn have you used in creating slides for your child? (Check all that apply)	Text (4)	Picture (5)	Audio Recording (3)		
8	Do you feel that iCanLearn provides you flexibility in designing the content of the skill that you want to teach your child?	Strongly Agree (1)	Agree (4)	Disagree (0)	Strongly Disagree (0)	
9	How many times have you used iCanLearn in the past two weeks?	1-3 times (2)	4-6 times (2)	7-10 times (1)	11+ times (0)	
10	List the different scenarios in which you have used iCanLearn (e.g. - to teach how to brush your teeth, how to get ready for school, how to greet someone, etc.)	Do laundry, Wash dishes by hand, Beginning of the day routine, Toileting routine, Waiting your turn, How to brush teeth, Putting back toys and other stuff				
11	Have you and your child used iCanLearn on two different devices connected in Teacher-Learner mode over a Wi-Fi network?	Yes (2)	No (3)			
12	If yes, how many times have you used iCanLearn in Teacher-Student mode in the past two weeks?	1-3 times (2)	4-6 times (0)	7-10 times (0)	11+ times (0)	Not Applicable (3)
13	Do you feel that your child is able to learn from iCanLearn on his/her own?	Strongly Agree (0)	Agree (5)	Disagree (0)	Strongly Disagree (0)	
14	Based on your experiences, would you recommend iCanLearn app to others?	Definitely (4)	Probably (1)	Maybe (0)	Probably not (0)	Definitely not (0)
15	What, if anything, about iCanLearn really pleased you?	Super easy and fast to build flashcards, Ease of use, has text, picture and audio features, nice graphics				
16	What, if anything, about iCanLearn really disappointed you?	I had to label the slides (a., b., c., etc.) to put them in sequential order				

\*indicates the number of participant who selected that option

## B. Participants

Parents or primary caregivers of children with ASD for the study were contacted by posting an IRB approved flyer in newsletters for the Autism Society of Southeastern Wisconsin (ASSEW) and Waukesha County – Children with Special Needs Listserv.

## C. Procedure

The approval for this study was received from University’s IRB (Institutional Review Board). The study was conducted in two parts – Pre-Survey and Post-Survey. The participants were provided with a link to a web-based survey (called, Pre-Survey). This link provided the participants an opportunity to consent electronically before being directed to the pre-survey. Informed consent was obtained prior to data collection. Participants were provided with the contact information of researchers working on this project, so they could ask questions.

The pre-survey questionnaire was aimed to assess the anxiety being experienced by a parent or caregiver. They were told to think about a situation where they were trying to teach a social skill or any daily activity to their child. They were asked to self-rate themselves on a six-item short form of the STAI. They were then given instructions on how to install the mobile app ‘iCanLearn’ on their Apple devices (iPhone or iPad). They were advised to use the app as many times as possible for next two weeks. The only personal information collected from the participant was his/her email address. This email address was used to contact that participant to provide him/her with the link to another web-based survey (Post-Survey) as well as the reward email. At the end of two weeks, they were contacted individually via email containing the post-survey link. Post-survey comprised of 3 parts: 1) self evaluation for measuring the anxiety level experienced by the subjects while teaching a certain activity to their child knowing that the mobile application can be used to their aid, 2) evaluation of the mobile application in terms of ease of use, features and overall user experience and 3) demographic questionnaire for statistical purposes. Each participant was given an Amazon.com gift card worth \$15 after the completion of post-survey to thank them for their time.

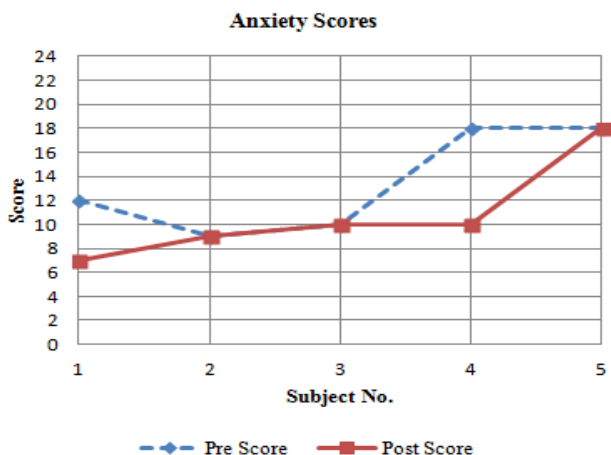


Fig. 4. Comparison of pre and post anxiety scores

## D. Results

For the initial survey, there were 20 participants and 5 of these also completed the post-survey questionnaire. The participants’ anxiety level before and after using the ‘iCanLearn’ app did not rise in any of the participants. Figure 4 shows the comparison of pre (dashed line) and post (solid line) anxiety scores of the 5 participants. Table II shows the results of users’ experience with iCanLearn (the number in parenthesis indicates the number of participants who selected that particular option). All the participants agreed on how the app is easy to use for parents as well as their children. Other favorable feedback obtained from participants included the following information about the usefulness of the ‘iCanLearn’ app:

*“...I made a set for washing dishes, 6 steps. It took about 5 minutes to build it, SO easy, and fun! You just snap a picture, record your instruction, and give it a title. It could not be any easier. I love it!”*

*“It was a pleasure to participate in the study, and will continue to use the app.”*

One participant commented that the slide titles he created for each slide subsequently determined the order of the slide presentation, alphabetically. There was no instruction that the participant should have numerically labeled each slide in order to keep slides in correct sequence. This was a very helpful comment and the instructions now indicate that the titles should begin with a number to keep them in order.

## VI. DISCUSSION

The objective for this research was to create a solution for parents and people working with children with ASD that would enable them to:

- Use a more individualized approach to creating learning content
- Easily create and edit flashcards or social stories
- Review flashcards with others while minimizing interruption of routine, while the teacher or parent manipulates the content
- Employ the use of auditory and visual learning

The development and release of the iCanLearn app has accomplished the intended goals. iCanLearn fosters a learning environment where the educational material is created specifically for an individual child. It allows for the use of audio recording and playback with a picture to stimulate both auditory and visual learners. With iCanLearn, it is possible to connect two or more devices in a teacher-learner relationship over a Wi-Fi network, allowing the learner to hold the device, giving them a sense of control while the teacher controls the content. Lastly, in the “creating and editing slides as a teacher” section earlier in this document it was illustrated that it is quite a simple, easy process to create and edit flashcards



within iCanLearn. Table III summarizes the key features of iCanLearn.

TABLE III. FEATURES OFFERED BY ICANLEARN

Mobile Software	Custom Content	Control Remotely	Audio	Pictures
iCanLearn	✓	✓	✓	✓

The first aim of our evaluation study was to examine the change in anxiety level of parents of children with ASD before and after using the mobile app – iCanLearn. From our study, we found that using the app did not have any adverse effect on the anxiety level of parents. The anxiety level after using the app either remained unchanged or it lowered down from the level experienced before using the app - iCanLearn. Anxious parents are at risk of heightened anxiety [22] and at risk for disrupted recall of information, so it is important for the technology to be simple and easy to use. The second goal of the study was to assess the usability of this app in terms of its design and features. The response provided by the participants is clearly indicating towards the ease with which this app can be used by children and their parents alike. This ease of use definitely stems from the design considerations behind this project.

The evaluation of the app has limitations. The sample size is small. Since this app comes with a social benefit, we did not want to restrict the users from using this app by first launching a trial version for this study. After the pre-survey, once the users got to know about the app and what it could be used for, the \$15 gift card did not appear to be enough of an incentive for them to participate in the second part of the study. The data we received, even with the small sample was helpful, especially the comment on the numbering of the slides. The users’ range of topics for the social stories and flashcards, as well as the comment about not needing an in person demonstration of how to use the app validate the acceptability and feasibility of the app.

Since iCanLearn launched in October of 2012, it has downloads exceeding 1,000 in February of 2013 while sporting an average rating of 4.5 stars. There is a real potential that iCanLearn could have a broad impact on our society by improving the way we conduct autism interventions and education.

## VII. CONCLUSION

This paper explored how different areas of computer science are being used to help children diagnosed with ASD learn and potentially improve their quality of life. It focuses on how mobile computing is being used in general and gave brief descriptions of select games being used in the education of children with ASD. It reviewed select flashcard apps that were designed for the same purpose. Finally, the iCanLearn flashcard application was introduced with a discussion of the design and development processes, followed by some dialogue about the end user’s experience. We also presented the results of our IRB approved evaluation study of the app, which

suggested that the app has good acceptability and feasibility for the intended users. The app does not adversely affect the anxiety level of caregivers.

iCanLearn provides a new service to parents and teachers, helping them give children with ASD the care and education they need. This will ultimately result in children with ASD reaching a higher state of functionality and quality of life. Future improvements can still be made long after the initial release. Feedback from users in the app store will drive future updates. Two enhancements under consideration are: allowing devices to connect without Wi-Fi (ad-hoc) and allowing people to draw pictures instead of taking them or pulling them from their photo library. Future research could test the app for acceptability and feasibility.

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