

# Icanlearn: A Mobile Application For Creating Flashcards And Social Stories<sup>tm</sup> For Children With Autistm

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iCanLearn: A MOBILE APPLICATION FOR CREATING  
FLASHCARDS AND SOCIAL STORIES™ FOR  
CHILDREN WITH AUTISM™

by

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ABSTRACT  
iCanLearn: A MOBILE APPLICATION FOR CREATING  
FLASHCARDS AND SOCIAL STORIES™ FOR  
CHILDREN WITH AUTISM

Aaron P. Zaffke B.S.

Marquette University, 2013

The number of children being diagnosed with Autism Spectrum Disorder (ASD) is on the rise, presenting new challenges for their parents and teachers to overcome. At the same time, mobile computing has been seeping its way into every aspect of our lives in the form of smartphones and tablet computers. It seems only natural to harness the unique medium these devices provide and use it in treatment and intervention for children with autism.

This thesis discusses and evaluates iCanLearn, an iOS flashcard app with enough versatility to construct Social Stories™. iCanLearn provides an engaging, individualized learning experience to children with autism on a single device, but the most powerful way to use iCanLearn is by connecting two or more devices together in a teacher-learner relationship. The evaluation results are presented at the end of the thesis.

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## CHAPTER 1: INTRODUCTION

Diagnoses of autism spectrum disorder (ASD), condition that hinders communication and forming relationships, are on the rise (Falco, 2012; Autism and Developmental Disabilities Monitoring [ADDM] Network 2008). At the same time, mobile computing is permeating every aspect of our lives with the use of smartphones (Whittaker, 2012) and tablet computers (“Tablet Computer,” 2012). It seems like a logical step to use the latter to help the former. Mobile devices are always at the ready to provide an engaging learning experience. One can see the importance of autism treatment and intervention. People with ASD have real potential to make valuable contributions to our society. Mobile computing can help unlock that potential (Staley, 2012).

It is believed that with effective treatment and intervention, many of the children that have been diagnosed with ASD can learn to cope with their condition and go on to live happy, productive lives (Myers & Johnson, 2007). A mobile flashcard application would help parents and teachers of children with autism to create and edit Social Stories™.

This software would allow these teachers and parents to review learning content with an autistic child in a way that gives the child a sense of control by allowing them to have and hold their own mobile device. It would minimize the amount of personal contact that would otherwise be necessary, helping socially impaired children to focus on the content rather than other distractions. An individualized approach to learning is more effective with children with autism (Kane 2007; Koegel, Shirotova & Koegel, 2009), especially when making use of audio and pictures. That is why iCanLearn was created. It is an educational

flashcard app that allows one to create one's own content with text, pictures, and audio and connect multiple devices together in a teacher-learner relationship. iCanLearn, is a mobile application that has the potential to enrich the lives of those with autism and those that care for them by providing the following:

- Encouragement of an individualized learning approach by making it easy to create and edit flashcards based on the specific needs of a child
- Minimizing the amount of personal contact necessary for reviewing flashcards by connecting multiple devices in a teacher-learner relationship, enabling children with autism to learn without first having to overcome their social impairments
- Provides an engaging experience for children with autism by making use of audio and pictures

The second chapter of this thesis describes the motivation behind the project, and how the needs for an app like iCanLearn were identified. Chapter 3 consists of a general discussion about other work in the computer science field that relates to helping children with autism. iCanLearn is introduced and described in Chapter 4. That chapter includes details about key features and design choices for the app. User scenarios are presented in Chapter 5 showing how one would create, edit, and view slides. Chapter 5 also illustrates how to connect two or more devices together in a teacher-learner relationship. Chapter 6 lays out how one may use iCanLearn for producing Social Stories™. In Chapter 7,

iCanLearn is evaluated according to the features it provides as a learning tool and details about its successful launch are dispelled. Chapter 8 concludes the thesis by giving consideration to the contributions of the app and taking a brief look at what's in store for the future.



## CHAPTER 2: MOTIVATION

Flashcards and Social Stories™ are effective, popular tools for educating children with autism (Higgins, McLaughlin, Derby, & Long, 2012; Kokina, & Kern, 2010). That is why a flashcard app with the ability to create Social Stories™ was pursued.

To further illustrate the motivation behind this project, some scenarios will be discussed. These scenarios are purely hypothetical. Any resemblance to a real person or situation is completely coincidence.

### 2.1 Scenario 1

Consider a schoolteacher who works with children who have learning disabilities. The teacher creates flashcards for the concepts and topics that each student is working on. This works well for some students, however, there is a boy with autism who 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 notices that many of the drawings on the flashcards do not seem to make sense to the boy. The teacher experiments with cutting out pictures from magazines, downloading images from websites, and taking pictures of things, printing them out, and then gluing them to the flashcards. This method seems to work better, especially when using pictures of familiar things to the boy like items from around the school. It is time consuming to create flashcards this way. The teacher lacks the freedom of drawing a new flashcard on the spot if the boy does not understand the drawing on the first flashcard.

In teaching the children about vehicles and transportation, the teacher has found that another boy with autism is unusually fascinated with certain flashcards, especially ones that have trains on them. The boy likes to hold these cards in his hands and look at them for long periods of time. Sometimes, when the teacher tries to take them away, or encourage the boy to flip to the next card, the boy screams and yells. The teacher tries holding the cards while reviewing them with the boy, but he becomes disengaged when he cannot hold and flip through the cards himself. The teacher tries removing the cards from the stack, but sometimes it's hard to predict which cards, besides the ones with pictures of trains, will capture the boy's attention.

What could be done to improve this teacher's situation? She needs an easy way to create and revise flashcards. The teacher would also appreciate a way reduce the amount of personal contact involved while reviewing the flashcards with students. 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.

## **2.2 Scenario 2**

The parents of an autistic girl have been having difficulties getting her to cooperate in the mornings while waking her up and preparing her for school. They create a Social Story™ that illustrates the “getting ready” situation with appropriate behaviors and responses (“What Are Social Stories™?” n.d; More, 2012), 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 and tries to shorten them.

The parents 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 (Crozier, & Sileo, 2005). 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 (Wetherby, & Woods, 2006).

### **2.3 Characteristics of the Application**

The objective of this project is to help people in situations similar to these scenarios. The goal is to create an application that helps people:

- Easily create and edit flashcards
- Review flashcards while minimizing personal contact

- Give learners a sense of control by allowing them to hold a device with flashcards on it, while the teacher or parent manipulates the content
- Create learning content that is sensitive to the individual needs of a child
- Employ the use of auditory and visual learning

## CHAPTER 3: RELATED WORK

Prior to developing any product, it's a good idea to take a look at what's already been done. This helps avoid duplication of efforts, and it can also serve as inspiration. This benchmarking step played a key role in the design and development in iCanLearn. Many computer-based efforts to help people with autism were examined. Some of these are discussed in this chapter.

### 3.1 Affective Computing

The goal of affective computing is to make systems and devices responsive to a person's current state of being (M.I.T Media Laboratory Perceptual Computing Section, 1995). For example, your music player might monitor your emotional state to play songs that cheer you up when you are sad and songs that sooth you when you're upset. This could be made possible through wearable computers that could measure vital signs, for example body temperature and heart rate, while cameras in the environment monitor facial expressions. These devices would communicate with your music player, which would pull from pre-selected play lists that you marked as "soothing" or "cheerful".

### 3.2 Wearable Computers

A lot of good work is being done in the area of wearable computers to help people with ASD. Some projects allow people with autism to examine their patterns of response in social situations. This helps them to understand how they appear to others. A few examples are glasses that detect facial expressions, gloves that detect skin conductance, heart rate

monitors, and even wearable camera systems (El Kaliouby, Picard, & Baron-Cohen, 2006). The data collected from these devices is used to educate someone with autism about himself or herself, helping to improve the way he or she relates to others. For example, a high functioning person with autism might review videos taken of them and/or others from a wearable camera system to help them associate facial expressions with emotions. This process helps a person with ASD develop a better understanding of what kinds of facial expressions others are expecting them to make during certain interactions. For example, they may learn that when someone smiles at them, they should smile back.

Wearable computers could also be used in a classroom setting to help predict and avoid disruptive behavior (Steele & Steele, 2002). Students with disruptive behavior patterns could wear sensors that monitor them for physiological changes that happen just before an outburst. The teacher and/or the student could then be alerted prior to the outburst, and steps could be taken to get the student back on task while minimizing the interruption to the other students in the classroom.

Discussed research in wearable computers was taken into consideration during the design and development of iCanLearn. The conception of the teacher-learner relationship and the idea of multiple devices connecting and communicating drew heavily on findings and the ideas considered in the research of wearable computers.

### **3.3 Robotics**

The use of robotics to help people with autism seems like a promising initiative for many reasons. Robots are more predictable and consistent than humans, often times making

them more preferable company in an autistic world. For this reason it may, ironically, be easier to teach things like social interaction skills to a person with autism through a robot instead of traditional teaching methods.

A longitudinal study was conducted with humanoid robots to examine the potential of using robots in autism intervention (Robins, Dautenhahn, te Boekhorst, & Billard, 2004). The goal was to get the children with autism to imitate the humanoid robot; social interaction skills are learned through imitation. All of the children in the study grew comfortable with the robot and, as a result, they began to interact with the investigator and others to share their experience.

Another longitudinal study used a robotic basketball hoop and sensors to detect the affective states, like anxiety and engagement levels, of the participating children (Liu, Conn, Sarkar, Stone 2008). A robot was programmed to move a basketball hoop in certain directions and speeds while several kinds of music were played. The behavior of the movement of the basketball hoop and the music would vary based on the child's affective states while attempting to shoot baskets. For example, if a child found an activity too easy and started getting bored with it, the robot would try a different behavior that might be more challenging and exciting. The robot would try to make it challenging enough to maximize engagement and enjoyment without making it too difficult and produce anxiety in the child.

This research in the area of robotics influenced iCanLearn. The idea of changing difficulty levels in the above example with the basketball hoop carries through in the teacher-learner relationship part of iCanLearn. Teachers and parents can monitor a child's behavior and change the learning content accordingly.

### **3.4 Touchscreen Software**

TouchStory is an educational computer game designed for helping children with autism improve relational skills by working to strengthen their narrative comprehension (Davis, Dautenhahn, Nehaniv, & Powell, 2007). It was developed for use with a touch screen monitor because many children with autism have trouble using a mouse and keyboard. In the game, the children are presented with several “TouchStories” – a screen with two rows of pictures, one on the top and one on the bottom. The row at the top consists of sequential pictures with a fourth space or gap where the child is supposed to drag the missing piece of the sequence from the three choices at the bottom. For example, the top row might have a picture of a carton of eggs, then a picture of an egg frying on the stove, then a gap, and then a picture of a plate that has been dirtied by the consumption of an egg. The child is supposed to recognize from the three images in the bottom row that the missing piece to the TouchStory is a picture of a plate with the cooked, uneaten egg on it. If the child drags the correct picture into the gap, they are visually rewarded, and if they drag the wrong picture, they are given encouraging feedback coaxing them to keep trying until they get it right.

### **3.5 Mobile Computing and Educational Games**

Many people have found mobile gaming to be quite helpful while working with children with ASD (Apple Inc. 2012). It has been quite useful in education. There are many elements that contribute to the effectiveness of games as an educational tool for children with ASD. Games are engaging. Most mobile games have attractive graphics and sounds.



They are entertaining and hold the child's attention for extended periods of time. This usually leads the children to repeat playing the game.

Larger knowledge transfer, the amount of information being absorbed by the learner, and a higher retention rate of that information are two more reasons why games are effective educational tools for children in general as well as children with ASD. A child's ability to learn is affected by his/her mood (Lewis, 2003). A game can put a child in a happy mood, increasing the possibility of knowledge transfer. Also in games, there is a certain amount of repetition. The more a child does something, the higher his/her retention rate will be (Saville, 2011).

Formulas for making great mobile educational games were closely studied prior to designing and developing iCanLearn. Although iCanLearn is a flashcard app, and not an educational game, some of the success factors from educational games, such as audio and visual components, are incorporated into iCanLearn to make more effective.

A great way for children with ASD to learn deductive reasoning and problem solving skills is by playing puzzle games (Eun-Young & Young-Ho, 2010). Many puzzle games are cause and effect oriented and physics based. They allow children to rearrange the environment, removing obstacles, changing object's rotations, etc. in order to get something from point A to point B.

A good example of one of these physics based games that teach children deductive reasoning is a game by Disney® called Where's My Water? ("Where's My Water?" 2013). In this game there is an adorable alligator named Swampy who is trying to take a shower. He is having some difficulties, however, because the plumbing is broken and the water is blocked

in the sewer. The object of the game is to get the water into Swampy's shower. The player must change the environment by 'digging' paths in the dirt with their finger for the water to flow to Swampy's shower while avoiding obstacles along the way.

Some levels have acid in them, and the child must direct the flow of the acid so that it does not mix with the water (TylerColeSmith, 2012). Sometimes the child has to direct the acid to a part of the level where there is green algae or fungus to dissolve it. Then they have to direct the acid away and wait for it to clear before they can run the water by it. This helps them think through problems from start to finish. It helps them to grasp the concept of cause and effect.

Where's My Water? has a number of elements that engage children and hold their attention (Price 2011). Swampy is very cute and entertaining. When the child succeeds in getting him water, he celebrates and scrubs his back with a brush. When the child does not succeed and accidentally lets all the water drain away somewhere else, Swampy cries. Swampy screams in classic cartoon comical pain if a child allows the acid to reach his bathtub. Another thing the creators of this game did to keep children engaged is that they added collectibles. Every level has three rubber ducks that you can collect by flowing the water to them before going to Swampy's shower. Some levels have a mystery item that you can find while clearing out dirt.

Apps like Where's My Water? influenced some design choices made during the development process of iCanLearn. The use appealing graphics was noted when reviewing Where's My Water? serving as inspiration to incorporate an attractive design. This led to the chalkboard theme of iCanLearn.

Shape Builder - the Preschool Learning Puzzle Game by Darren Murtha Design is an app that simulates simple jigsaw puzzles (“Shape Builder” 2011). The child touches and drags different colored shapes into an outline of a larger, meaningful shape, like the outline of a letter or musical instrument. When the player drags all the shapes to their appropriate places, the large outline changes into a cartoon drawing. This keeps the child engaged; they might not discern what the shape is before it’s all put together, and that creates a degree of anticipation. Sound effects that go with the puzzles also serve to keep children engaged (funforpreschool 2011).

Learning how to read and write can be difficult for any child, but it’s especially difficult for children with disabilities like ASD. There have been some marvelous apps published to help children learn how to read and write. Some examples will be discussed below.

iWriteWords by gdiplus is an app that teaches children how to write and spell (“iWriteWords”). It does this by providing the child with an outline of the letter with colored numbered dots inside, allowing a child to slide his or her finger along to connect the dots and make a letter. The first dot is a little cartoon crab that is quite appropriately named, “Mr. Crab”. Mr. Crab follows as the child drags his/her finger through the shape of the letter. iWriteWords uses bright colors and other cartoon animas to grab the attention of the learner. For example, after the child spells “cat” a cartoon drawing of a yellow cat appears (mykidappreviews 2010). The developers of iWriteWords had some fun with a 2-d physics engine to keep children engaged. Each time a player correctly writes a letter, a block containing that letter falls down from the top of the screen and bounces around. The player

can drag it around with their finger, or flick it to make it bounce off the sides of the screen and other objects. Tilting the device also makes the blocks slide around. When a player has spelled the whole word, he or she can drag the letters into a spinning black hole or tilt the device so they fall into it.

Little Speller Site Words by Grasshopper Apps teaches children how to spell, speak, and read while they learn how to recognize letters and words by their sight and sound (“Sight Words” 2011). In this app, the child sees a word centered in the background of the screen. The blocks of the letters that make up that word are scattered around it. At the bottom of the screen are squares containing each letter, spelling out the word. The child must drag the letters to their appropriate places. In the settings of the app, you can make it so they have to spell the word in order. It won’t let them start in the middle of the word; they have to start with the first letter, move on to the second, and so on to finish the word (tinytubeful 2011).

Little Speller Site Words app makes use of audio to increase knowledge transfer and hold children’s attention. Audio of the word plays immediately when it appears. When the player touches a letter and starts dragging it, audio of that letter plays. This helps children with their pronunciation. When the child correctly spells the word, it says, “Well done! You correctly spelled the word: [\_\_\_\_\_]”. Then it spells the word for them, speaking each letter while the blocks of each letter bounce up as they are being spoken.

Little Speller Site Words does not display negative feedback when a child drags a letter into the wrong place. This is intended to keep children engaged for longer periods of time. Instead, the letter simply just bounces up and away from the word at the bottom of the

screen. This helps keep the player focused on spelling instead of worrying that they are going to make a mistake. Negative feedback such as, “Oops! Try again.” can be disruptive to a learner, and he/she might not stay tuned into for very long.

Rocket Speller by Little Big Thinkers is another excellent word and spelling game. It has a similar user scenario to Little Speller Site Words (“Rocket Speller” 2012). However, they’ve done some interesting things to grab and hold a child’s attention.

One simple way the developers of this app increased its effectiveness as a learning tool is by showing a picture of the object associated the word the child is expected to spell. This picture appears in the upper right hand corner of the screen. For example, a picture of a truck would appear if the word were “truck”. Seeing a picture of the object helps the child comprehend the meaning of the word.

A loveable character is attractive to children. Using one will increase the amount of time they are willing to participate in a learning game. There is a cute little alien avatar in a flying saucer perched in the upper left corner of the screen. He does all the talking. He says the word the child is to spell and he speaks the letters as they are dragged into place.

Rocket Speller also keeps children tuned in by giving them a goal to work towards: build a rocket and fly it through outer space. The rocket consists of three sections - top, middle, and bottom. After every third word spelled, the alien descends down to a planet, where the player can pick from several different styles of components for the rocket. After the player has collected all three sections and another three words are spelled correctly, the alien descends down to another planet, where he assembles the rocket and gets in. The player gets to press the launch button to make it take off. While it’s flying through outer

space, the player can steer by dragging their finger on the screen. As the ship travels, stars are collected from the words they spelled.

Progress is made visible to the player in a number of ways. This serves to maintain interest. When the player spells the word, the alien flies through space to the right, giving the child the impression that they are going somewhere. Outlines of stars and the parts of the rocket they are building are on the bottom of the screen for each word they need to spell. When they spell a word correctly or pick a rocket section, a star or rocket part spins around in the outline and then stops as the alien starts flying to the next word (Price 2012).

The developers of Rocket Speller wanted to make it easy to understand and play. They wanted to know the points in the app where children stopped playing, so they could readdress and revise the app. Their website boasts that through a process of A/B testing their completion rate, how many times someone plays from start to finish, grew from 23% to 42%. The developers increased the number of games per session from 1.1 to 1.3 (Little Big Thinkers Inc. 2012).

There is a possibility that this same thing could be done with iCanLearn to make it a more effective learning tool. Analytics have been built into the app to identify screens where people seem to have trouble and stop using the app. Future updates to iCanLearn can address those difficult areas to make iCanLearn more user-friendly.

### 3.6 Flashcard Apps

There are hundreds of flashcard apps for iOS and Android. Each one fulfills a specific niche by providing a different combination of common features. These features can be broken down as follows (“Flashcard Apps,” n.d.).

<b>Table 1</b> <i>Common features in mobile flashcard apps</i>	
Feature	Common implementations
Ready made cards	Quizlet
	Study Stack
	Flashcard Exchange
	ProVoc
Share	Wi-Fi
	Bluetooth
	Email
Import and export	Text files
	Spreadsheet
	Comma separated values file (CSV)
	Tab separated text file
Tracking	Flag cards
	Leitner boxes
	Spaced repetition systems (SRS)
Sync	Cloud based
	Website version
	Wi-Fi
	Bluetooth
	Desktop version
Extras	Images
	Sounds
	Text-To-Speech
	Look up description or translation

Some of these flashcard apps were designed for Applied Behavior Analysis (ABA) programs to help children with autism. Applied Behavior Analysis is a process for improving

social behaviors in an individual (Cooper, Heron & Heward, 1987). These apps usually have pre-made slides that contain pictures, sound, and text. Many flashcard apps were reviewed prior to designing and developing iCanLearn. Benchmarking other flashcard apps was important to get a good understanding of what has been done already and how to improve upon it.

The typical learning session using one of these apps goes something like this: the parent/caregiver of the autistic 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.

A lot of ABA flashcard apps available today are aimed specifically at typical symptoms of autism such as associating facial expressions with 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 suffering from ASD to identify, understand, and respond appropriately to emotions ("ABA Flash Cards & Games – Emotions" 2011).

The Emotions flashcard app has over 200 images of children varying in culture and ranging in age from infants to teenagers that are portraying one of 20 different emotions. There are two modes for playing: Learn and Game. In Learn Mode, the user goes through the cards with various customizable settings for audio, text, timing, etc. In Game Mode, the



user is presented with an emotion and must choose a picture or word corresponding to the emotion.

Another ABA flashcard app named Actions by kindergarten.com is specifically designed for teaching children with ASD. It teaches a variety of verbs like smiling, laughing, sleeping, etc. There are 52 flashcards in total, each one consisting of a title, an image, and an audio clip (“ABA Flash Cards – Actions” 2009). Each audio clip is the clearly spoken verb that the picture portrays. It is designed to promote language skills; children using the app can repeat the word to work on their pronunciation. The use of images text and audio helps to stimulate both visual and auditory learners. Sometimes the Actions app will randomly play a piece of classical music while graphics of musical notes animate around the screen. This entertainment is intended to keep children interested.

Social Stories is an ABA app that allows people to create and edit flashcards for the purpose of illustrating and telling Social Stories™ (“Social Stories” 2012). 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.

### **3.7 Characteristics of Mobile Learning Apps for Children with Autism**

Most of the apps mentioned above engage children with audio and visual elements. Some of them allow 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. See table 1 for comparisons of the mobile software noted in this discussion.

<b>Table 2</b> <i>Comparisons of features in mobile software</i>				
Mobile software	Custom content	Control remotely	Audio	Pictures
Where's my Water?	No	No	Yes	Yes
Shape Builder	No	No	Yes	Yes
iWriteWords	No	No	Yes	Yes
Little Speller Site Words	No	No	Yes	Yes
Rocket Speller	No	No	Yes	Yes
Emotions	Yes	No	Yes	Yes
Actions	No	No	Yes	Yes
Social Stories	Yes	No	No	Yes

## CHAPTER 4: ICANLEARN



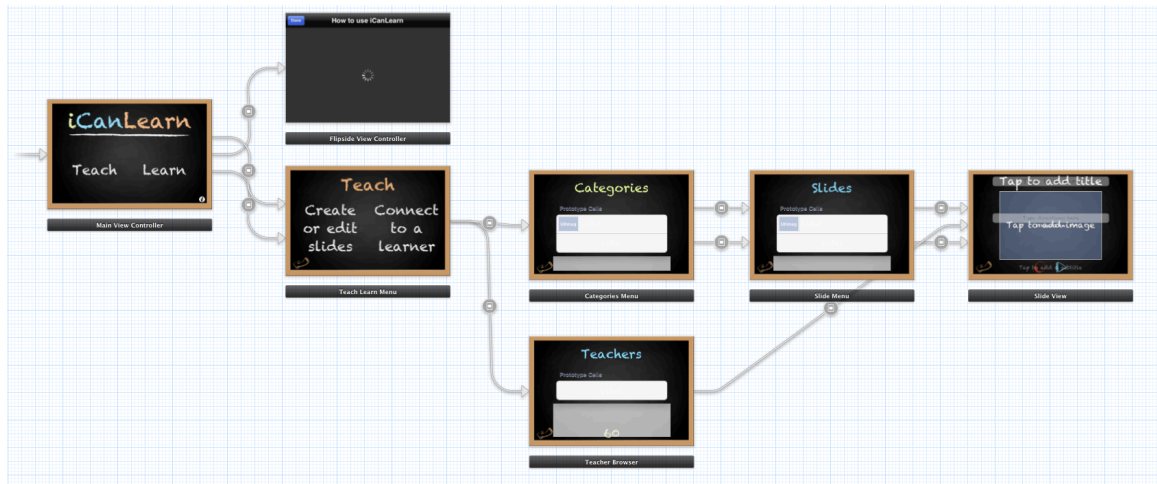
**Figure 1. iCanLearn icon.**

### 4.1 Overview of iCanLearn

iCanLearn is a flashcard educational app that allows for the creation of flashcards 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 for children. It is especially useful for reaching children that suffer from an ASD or other impairments in social functioning. It provides a medium for them to learn without first requiring them to overcome the social obstacle of allowing someone into their personal space while reviewing flashcards.

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.



**Figure 2. Screenshot of iCanLearn's iPhone storyboard in Xcode.**

## 4.2 iCanLearn Features

As mentioned above, iCanLearn is a flashcard app that offers the key features of text, pictures, audio, and connecting two devices in a teacher-learner relationship. There are many flashcard apps that offer similar features. However, as of this writing not one app has been discovered that connects two or more devices in a teacher-learner relationship. Many of the common features of flashcard apps were implemented into iCanlearn in unique ways.

### **4.3 iCanLearn Design**

When thinking about a design theme for iCanLearn, it was decided to use a design that most people associate with learning. Though it's going out of style at an ever-increasing rate, most people still recognize and can make the connection between a chalkboard and education. Therefore, a chalkboard theme was chosen for the app. A chalkboard graphic is utilized as the background for almost every screen. That theme was furthered by the use of a font called Chalkduster in most labels and text fields. The button graphics for the back arrow and audio controls were made to look like they had been drawn with chalk.

When thinking about how to transition from screen to screen, the desire was to make the chalkboard appear realistic. That is why it flips over in a 3-D animation. There is one exception to this, when you are viewing slides and you 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 flashcard then slides in from the opposite side of the screen to take the old flashcard's 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.

### **4.4 iCanLearn Text**

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, the subtitle text field was removed because it rarely got used.

#### **4.5 iCanLearn Pictures**

Implementing pictures wasn't as simple as one might expect. Much thought was directed at storing and retrieving 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.

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. This presented a choice point of whether or not to compress and resize images. 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 idea was to use less hard drive space and make the app perform faster. This would be especially noticeable when transferring flashcards to another device.

Later on, however, it became apparent 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 own screen.



**Figure 3. iCanLearn slide displayed on iPhone 4S  
with picture taken with its camera**



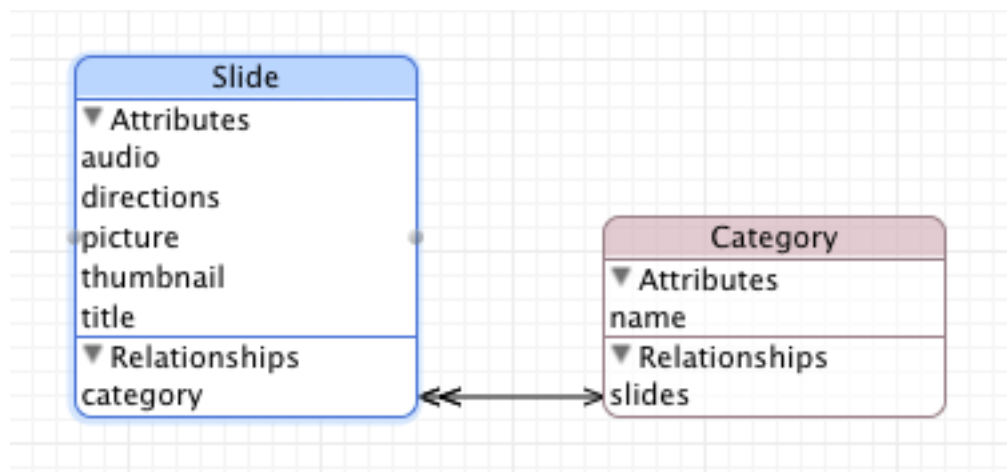
**Figure 4. iCanLearn slide sent from iPhone 4s teacher  
device displayed on iPad 2 learner device**

Figure 3 shows a slide created and displayed on an iPhone 4s with a picture taken with its camera. Figure 4 shows that same slide being displayed on an iPad 2 connected to the iPhone 4s in a teacher-learner relationship. Please, note that due to the constrictions of page size, these images are not proportional to each other.



## 4.6 iCanLearn 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.



**Figure 5. Core Data model of iCanLearn.**

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.

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.

#### **4.7 iCanLearn Teacher-Learner Relationship**

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 (“Quizlet,” 2013), Study Stack (“Study Stack,” 2013), or Flashcard Exchange (“Flashcard Exchange,” 2013). 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.

This teacher-learner relationship in sharing slides was pursued because it will be helpful for children who suffer from ASD or some other impairment in social functioning. It

provides a medium for them to learn without first requiring them to overcome a social obstacle. While in the long run it is best for a child with ASD to become more social, it shouldn't have to be a prerequisite to learning other important things.

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 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 a 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 among 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. Instead, users are encouraged to use the app in a teacher-learner scenario. In that setting, someone in a teacher role can decide which slides the person or people in the student role(s) 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, a syncing option was left out. 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.

## CHAPTER 5: USER SCENARIOS OF ICANLEARN

In this chapter 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.

### 5.1 Creating and Editing Slides as a Teacher

Creating and editing slides is the first thing users will do after downloading the app. Below is an outline of that process.

1. Select "Teach" from main menu



Figure 6. Main menu of iCanLearn

2. Select "Create or edit slides" from teach menu



**Figure 7. Teach menu of iCanLearn.**

3. Select or add a category



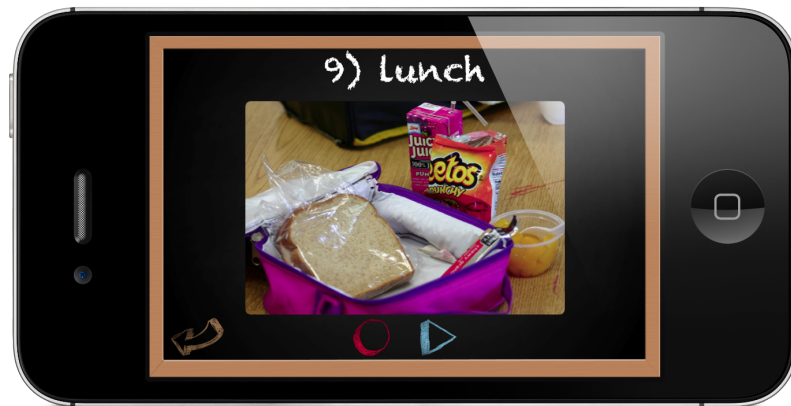
**Figure 8. Categories menu of iCanLearn  
in teacher mode.**

4. Select or add a slide



**Figure 9. Slides menu of iCanLearn  
in teacher mode.**

5. Edit slide by tapping on any of the elements



**Figure 10. Sample slide of iCanLearn  
in teacher mode.**

## 5.2 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



**Figure 11. Main menu of iCanLearn**



2. Select "View slides" from the learn menu



**Figure 12. Learn menu of iCanLearn.**

3. Select a category



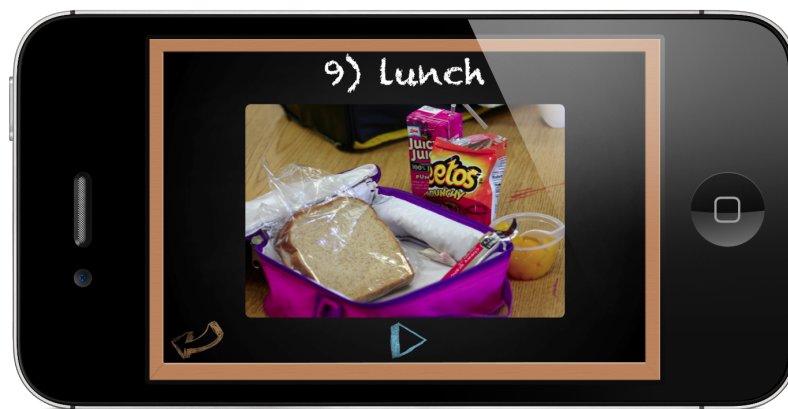
**Figure 13. Categories menu of iCanLearn  
in learner mode.**

4. Select a slide



**Figure 14. Slides menu of iCanLearn  
in learner mode.**

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



**Figure 15. Sample slide of iCanLearn  
in learner mode.**

### 5.3 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"



**Figure 16. Main menu of iCanLearn**

- b. Select "Connect to a learner"



**Figure 17. Teach menu of iCanLearn.**

3. On the other device(s):
  - a. Select "Learn"



**Figure 18. Main menu of iCanLearn**

- b. Select "Connect to a teacher"



**Figure 19. Learn menu of iCanLearn.**

- c. Select the device that you set up as a teacher



**Figure 20. Teachers menu of iCanLearn.**

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



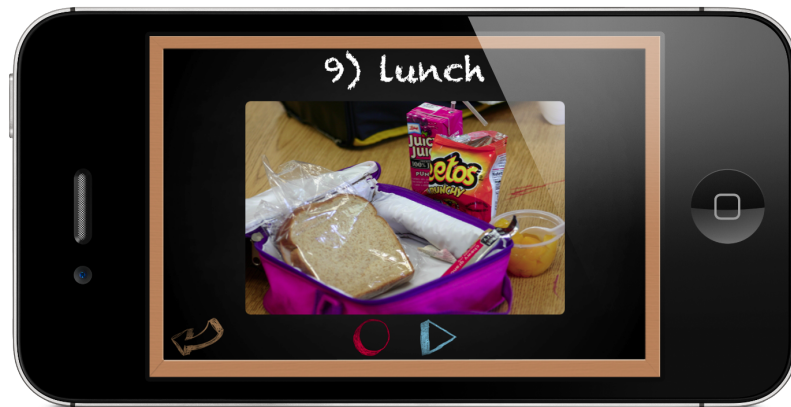
**Figure 21. Categories menu of iCanLearn  
in teacher mode.**

- b. Select a slide



**Figure 22. Slides menu of iCanLearn  
in learner mode.**

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



**Figure 23. Sample slide of iCanLearn  
in teacher mode.**

## CHAPTER 6: USING ICANLEARN FOR SOCIAL STORIES™

The use of Social Stories™ is a very popular technique for treatment and intervention of children with ASD. Social Stories™ have been found to be successful by multiple studies (Scattone, Wilczynski, Edwards, & Rabian, 2002; Crozier & Tincani, 2007; Ozdemir, 2008; Reichow & Sabornie, 2009). Carol Gray first defined Social Stories™ in 1991. They are stories that illustrate to an autistic child what kind of common behavior(s) are expected of them in certain situations. They help the autistic child understand how someone else might be feeling, and how they can respond appropriately (“What Are Social Stories™?” n.d; Gray, 1994).

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 an autistic girl who used Social Stories™ to get her to cooperate in the morning when it’s time to get up and get ready for school. iCanLearn could help people like her parents and their children. Parents and teachers could create a category in the app and give it the name of a Social Story™. Then, they could create flashcards in that category with pictures, text, and audio that help tell and illustrate the Social Story™.

We believe that iCanLearn and Social Stories™ can enjoy a symbiotic, mutually beneficial, relationship together. We believe that Social Stories™ told 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 autism 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.

Below is a Social Story™ written with inspiration from (Quirnbach, Lincoln, Feinberg-Gizzo, Ingersoll, & Andrews, 2009). Screenshots of iCanLearn have been added to illustrate of how this might be accomplished. In a real life situation, the pictures in the flashcards would ideally be of the child you are creating the Social Story™ for, but for the sake of this paper, all pictures were obtained them from (stock.xchng, 2009).

A lot of children go to school during the week. It's very important to get up with enough time to get ready before school.



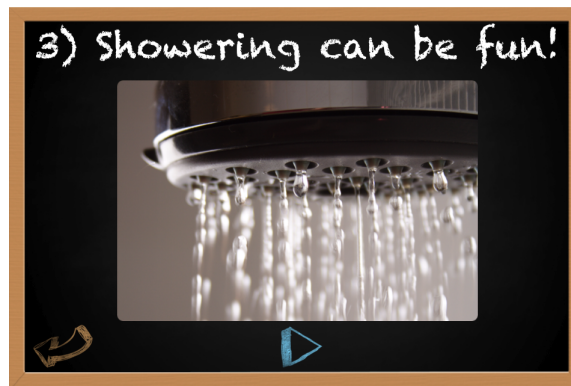
**Figure 24. Social Story™ example slide 1.**

My parents like it when I get out of bed right away after my alarm goes off. There are a lot of things to take care of in the morning before school.



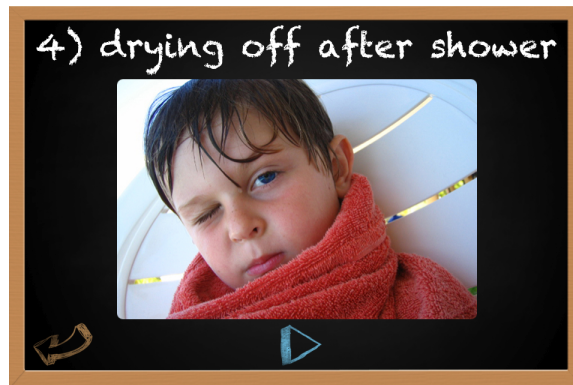
**Figure 25. Social Story™ example slide 2.**

I usually take a bath or a shower right after I get out of bed. Bathing helps me to wake up.



**Figure 26. Social Story™ example slide 3.**

After I bathe, I dry off with a towel.



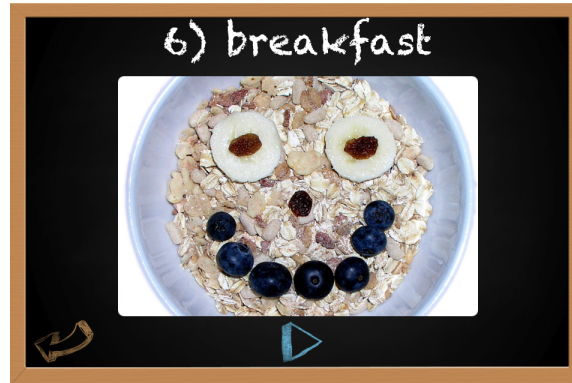
**Figure 27. Social Story™ example slide 4.**

After I dry off, it's time to get dressed. Sometimes my parents pick out my clothes. I am more comfortable when I'm dressed appropriately for the weather.



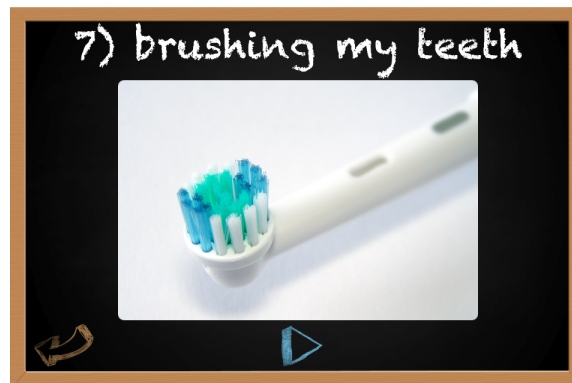
**Figure 28. Social Story™ example slide 5.**

I like to eat granola and blueberries for breakfast. If someone else is in the bathroom when I get up, I eat before I bathe. Other times I eat after I've bathed and dressed.



**Figure 29. Social Story™ example slide 6.**

Brushing my teeth after I eat is important. It gets rid of stinky morning breath.



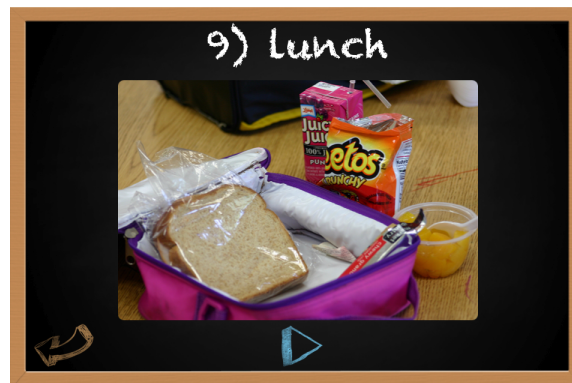
**Figure 30. Social Story™ example slide 7.**

I put important things in my backpack. I will have them at school when I need them.



**Figure 31. Social Story™ example slide 8.**

It makes my teacher happy when I do my homework and bring it to class. My mom usually packs me a lunch to bring to school in my backpack.



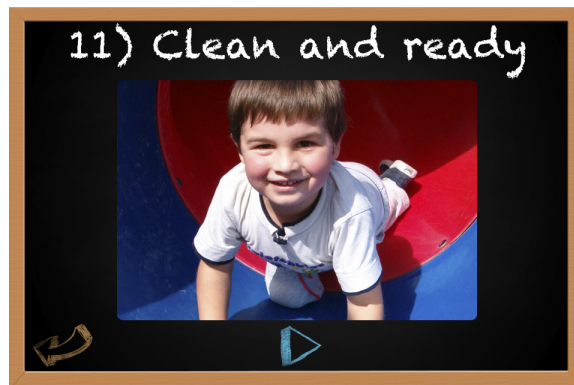
**Figure 32. Social Story™ example slide 9.**

School starts at 8:00 in the morning. My parents appreciate it when I get ready on time.



**Figure 33. Social Story™ example slide 10.**

It's a good idea to double check that I have everything I need in my backpack before I leave for school. I'll be clean and prepared when I get to school, and that will make me feel good.



**Figure 34. Social Story™ example slide 11.**

## CHAPTER 7: EVALUATION

The motivation for this project was to create a solution for parents and people working with children with autism that would enable them to:

- Easily create and edit flashcards or Social Stories™



**Figure 35. Screenshot of a flashcard  
being created in iCanLearn.**

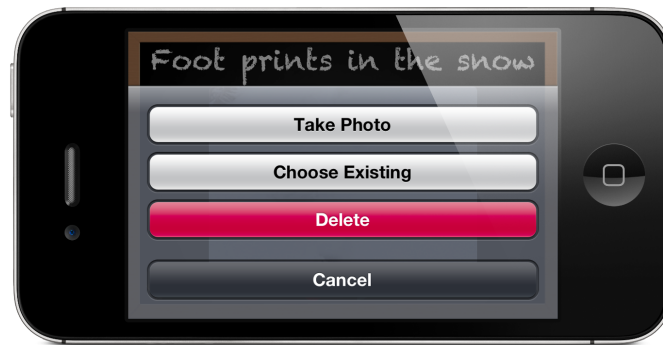
- Review flashcards with others while minimizing personal contact
  - Gives learners a sense of control by allowing them to hold a device with flashcards on it, while the teacher or parent manipulates the content



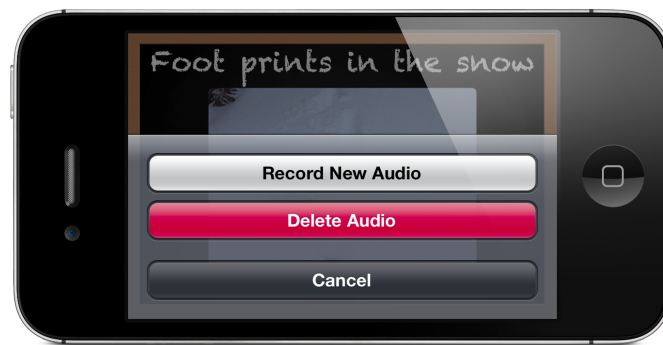
**Figure 36. Two devices using iCanLearn connected in a teacher-learner relationship.**

- Use a more individualized approach to creating learning content
- Employ the use of auditory and visual learning





**Figure 37. Adding a picture to a slide in iCanLearn.**



**Figure 38. Adding audio to a slide in iCanLearn.**

The development and release of the iCanLearn app has accomplished that goal. 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. This also allows for flashcards to be reviewed with very minimal personal contact.

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.

<b>Table 3</b> <i>Features offered by iCanLearn</i>				
Mobile software	Custom content	Control remotely	Audio	Pictures
iCanLearn	Yes	Yes	Yes	Yes

iCanLearn launched in October of 2012. It was exciting to see the number of downloads exceed 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 intervention and education.

## **CHAPTER 8: CONCLUSION AND FUTURE WORK**

### **7.1 Conclusion**

This thesis explored how different areas of computer science are being used to help those diagnosed with ASD. It focused on how mobile computing is being used in general and gave brief descriptions of a couple of games being used for educating children with autism, and reviewed some 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.

### **7.2 Contribution**

The iCanLearn app is unique in that it accomplishes the following:

- Minimizes the amount of personal contact necessary for reviewing flashcards
- Gives learners a sense of control
- Makes use of pictures and audio for a more engaging experience
- Fosters an individualized learning methodology

Thousands of people around the globe are already benefiting by using iCanLearn to serve the many individual learning and development needs of children with autism. It is providing a new service to parents and teachers, helping them give their children the care and education they need. This will ultimately result in children with autism reaching a higher

state of functionality. They will be growing up to live happier, more productive lives, and we will all benefit from their contributions to society.

### **7.3 Future Work**

The beautiful thing about mobile apps is that improvements can still be made long after the initial release. Feedback from users in the app store is the driving force behind future updates. Three enhancements under consideration are:

- Allowing devices to connect without Wi-Fi (ad-hoc)
- Allow people to draw pictures instead of taking them or pulling them from their photo library
- Allow people to share flashcards, either through a web service, or by direct transfer

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