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# Design Strategy for the Development of Applications for Autism Instruction

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# DESIGN STRATEGY FOR THE DEVELOPMENT OF APPLICATIONS FOR AUTISM INSTRUCTION

A Thesis

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For my husband and children who have provided me with their unconditional love, patience, and understanding during my continued absence that is also called graduate school.

In memory of my mother and my father who always supported me and encouraged a love of learning that has lasted throughout the years.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AAC | Alternative Augmentative Communication |
| ASD | Autism Spectrum Disorder |
| CAI | Computer Aided Instruction |
| DOC | Definition Outline for Collaboration |
| EPICS | Engineering Projects In Community Service |
| IEP | Individualized Education Plan |
| IPAAC | Interactive, Programmable, Alternative Augmentative Communication |
| GLASS | Greater Lafayette Area Special Services |
| OCR | Optical Character Recognition |
| PECS | Picture Exchange Card System |
| TSMC | Touch Screen Mobile Computers |

# ABSTRACT

Rasche, Nancy J. M.F.A., Purdue University, December 2013. Design strategy for the development of applications for autism instruction. Major Professor: Zhen Yu Qian.

This paper explains my journey of exploration into the development of a mobile application for children with Autism Spectrum Disorders (ASD) based on researching an area of instructional need. The direction spread to creating a tool to encourage collaboration between designers and educators to generate more mobile application educational opportunities for children with ASD. These two paths of development of touch screen mobile computer (TSMC) applications are explored in this paper. The first path of application development, based on a researched instructional need into improving the comprehension skills of children with ASD by teaching the emergent literacy skill of vocabulary with labels, is shown with the development of *Literacy Labels*. The second path is to develop an application based on a direct instructional approach that is being used with children with ASD that would benefit from automation in a mobile application. For this second path, the creation of the Definition Outline for Collaboration (DOC) is detailed. This path is for teachers, clinicians, therapists, parents, and/or those in the research community to document a possible design idea as a catalyst for

collaboration with the design community. The most effective application design for children with autism must start with an understanding of the user's unique instructional needs and both of these paths start with this strong foundation.

PUBLICATIONS

# Work in Progress: Application Design on Touch Screen Mobile Computers (TSMC) to Improve Autism Instruction

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*Abstract*— **This study identifies the areas of autism therapy that can be enhanced by using a touch screen mobile computer (TSMC) device to facilitate autistic children's learning experience. At an affordable price range, the simple touch screen of a TSMC has an immediate cause and effect response that enables these students to be more independent during the learning process. These key factors make the TSMC an ideal supplement for autism therapy in the classroom and for skill reinforcement at home. However, to identify a correct starting point is crucial for the success of this research. Our study aims to explore the most effective application design areas using a TSMC as an instructional tool for autistic children. To determine this direction, four main steps were identified. These steps include reviewing current literature on autism deficits, evaluating the interaction design of the TSMC, analyzing existing TSMC applications currently available, and designing a prototype application for evaluation. This paper reports our model of information processing interruption in autism learning, our target zones of instruction based on the literature review of autism deficits, and introduces our implementation plan of the application design to enhance autism therapy.**

***Keywords-autism therapy; computer aided instruction; instructional technology; cognitive deficits; cognitive information processing; application design; Touch Screen Mobile Computers***

## I. INTRODUCTION

Autism spectrum disorders (ASDs) are a group of developmental disabilities characterized by atypical development in socialization, communication, and behavior [1–3]. The significant increase in the prevalence of ASDs has led to an increase in research of related treatments. Currently, there are a wide range of assistive technology devices available that can be implemented by teachers, parents, and/or therapists. These items range from the low level visual cue cards to the high level computer assisted instruction (CAI) devices. Among the many assistive technology options, CAI provides the educational advantage of providing consistent and predictable feedback that can be repeated many times to reinforce skills. For such use, TSMCs stand out because of their potential price affordance, accessibility, and usability. The research topic of developing new applications for autism therapy on the iPad was inspired by Rasche's collaborative design experience with Purdue University's EPICS (Engineering Projects in Community Service) program. The team was developing a suite of iPad applications to be utilized as communication aids for children with autism and other special needs [4]. The success of these applications encouraged us to go one step further – conducting research upon what autistic children most need to improve their current learning condition, investigate possible paths to satisfy these needs with TSMC technologies, identify patterns through our design experience, and then encourage involvements from the design society to improve the education resources for autistic children.

Our research started from reviewing psychology literature to understand cognitive deficiencies associated with ASDs to determine instructional needs. Through integrating these findings with human cognitive information processing model, we drafted an interruption model to illustrate the problematic regions. Reviewing different TSMC devices provided an understanding of their interaction strengths and weaknesses in relation to being an effective tool for different ASD deficits. The comparison table of the cognitive deficits and TSMC potential will help us to locate target instruction zones and prospective paths that are suitable for application design on the TSMC. These steps pave the way to provide credibility to our possible designs. The goal of this thesis research is to create an interaction design framework to explore the potential, boundaries, and directions of developing TSMC applications for autism therapy.

## II. ENIGMA OF COGNITIVE DEFICITS

According to the literature review, we started to realize that ASD cognitive deficits constructed an enigma instead of an explicit list - every child diagnosed with autism will have a wide range of disabilities at many different capacities. Therefore, it is impossible to clearly list all the disabilities for all children with autism because it varies for each.

The summary of deficits list may be apparent in many, but not all of the individuals with an ASD with variable capacity. Therefore, it is necessary to have a detailed register of deficits for autism disorders that can be considered an area for needed focus in therapy instruction based on the individual's needs. The three general areas of cognitive deficits are theory of mind,


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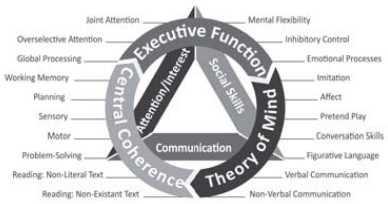


Figure 1. Target Zones of Instruction

executive function, and central coherence. These three deficit areas lead to the three most common areas of disabilities: communication, social skills and attention/interest. As shown in Figure 1, the deficits and disabilities create a long list of possible target zones of instruction.

Although, it is important to note that there is a connection between these deficits that can cause an increase or decrease in the capacity of the other disabilities. In other words, these deficits are linked, overlapped, and influence each other directly. To understand it further, we focus on the specific cognitive skills related with these deficits areas.

- Theory of Mind (ToM) can be described as an ability to understand the mental state of oneself and/or others [1], [5], [6]. ToM deficits are evident in children with ASDs as having difficulty understanding the perspective of others.
- Executive Function (EF) is the ability to make planning strategies to reach goals and having the flexibility to modify goals as necessary [1], [7], [8]. EF deficits are noted in children with ASDs as a strict coherence to routines and patterns.
- Central Coherence (CC) can be described as the ability to process information to achieve a whole, coherent meaning. Children with ASDs show exceptional skill at processing details, but the capacity to grasp inferred meaning in language and social settings is difficult [1], [8].

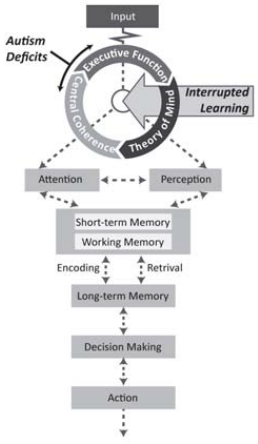


Figure 2. Information Processing Interruption Model

As a whole, it is clear that the cognitive deficits associated with autism cause an interruption in the processing of information [9]. As we illustrated in Figure 2, these deficits make attention and perception difficult to achieve and directly affect learning. Thus, the interruption in the processing of information reduces the amount of input translated to memory that can be later accessed to make appropriate decisions.

## III. Conclusion

We are currently reviewing TSMC devices to understand their interaction and examining available applications. Early research is showing a weakness in social skill instruction with the TSMC. This skill is best taught with one on one behavioral therapy approaches. Communication and attention are two areas that show a lot of promise. In fact, the research we saw with the communication application indicates that it draws more attention for effective information processing. The outcome of the final evaluation of the research studies and reviews will determine the application design direction. According to the develop plan, the first round of design and prototyping will start in July. This phase will include an evaluation of the prototype application with students, their families, and their educators through GLASS (Greater Lafayette Special Services) [4]. We aim to develop TSMC applications that will help supplement ASD instruction and connect family members to the child's learning experience at home with the help of digital media.

## References

[1] E. Pellicano, "Individual differences in executive function and central coherence predict developmental changes in theory of mind in autism.," *Developmental psychology*, vol. 46, no. 2, p. 530, 2010.

[2] C. Rice, "Prevalence of Autism Spectrum Disorders -- Autism and Developmental Disabilities Monitoring Network, United States, 2006.," *MMWR Surveillance Summaries*, vol. 58, no. SS-10, pp. 1–24, Dec. 2009.

[3] L. E. Schreibman, *The science and fiction of autism*. Harvard Univ Pr, 2005.

[4] "Glass EPICS." [Online]. Available: http://epics.ecn.purdue.edu/glass-at/. [Accessed: 16-Apr-2012].

[5] S. Fletcher-Watson and H. McConachie, "Interventions based on the Theory of Mind cognitive model for autism spectrum disorder (ASD)," *The Cochrane Library*, 2010.

[6] H. D. Schlinger Jr, "Theory of mind: An overview and behavioral perspective," *The Psychological Record*, vol. 59, no. 3, p. 7, 2010.

[7] S. Ozonoff, D. L. Strayer, W. M. McMahon, and F. Filloux, "Executive function abilities in autism and Tourette syndrome: An information processing approach," *Journal of child Psychology and Psychiatry*, vol. 35, no. 6, pp. 1015–1032, 1994.

[8] F. Happé, "Autism: cognitive deficit or cognitive style?," *Trends in cognitive sciences*, vol. 3, no. 6, pp. 216–222, 1999.

[9] J. G. Hollands and C. D. Wickens, *Engineering psychology and human performance*. Prentice Hall New Jersey, 1999.

[10] S. Stokes, "Assistive technology for children with autism," *published under a CESA*, vol. 7, 2000.

[11] S. Venkatesh, S. Greenhill, D. Phung, and B. Adams, "Cognitive intervention in autism using multimedia stimulus," in *Proceedings of the 19th ACM international conference on Multimedia*, 2011, pp. 769–770.

[12] A. L. Wainer and B. R. Ingersoll, "The use of innovative computer technology for teaching social communication to individuals with autism spectrum disorders," *Research in Autism Spectrum Disorders*, vol. 5, no. 1, pp. 96–107, 2011.

# Literacy LABELS: Emergent Literacy Application Design for Children with Autism

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(a) (b) (c) (d)

**Figure 1:** *(a) The user persona explains the autistic learner. (b) The two learning methods are scanning QR codes on labels and reinforcing skills by playing the game. (c) Sample of the mock-up and formative evaluation feedback. (d) Illustration of the final design and graphics.*

## 1 Introduction

We introduce the design and development of the iPad application, Literacy LABELS, which aims to help children with Autism Spectrum Disorders (ASD) develop the early literacy skills necessary to bridge toward reading and writing. There is a common thread among children with ASD to use decoding skills to read. This ability can even occur before they develop functional verbal communication. Yet, these children struggle with reading for meaning and lack the ability to comprehend text. (Randi, Newman, and Grigorenko 2010) This application is our effort on improving this situation. Labeling is used in many typical development preschool and kindergarten classrooms to help non-readers connect the orthography and the meaning of the word by placing a label on the actual object. Literacy LABELS was designed for the iPad to help children with ASD develop the skills necessary to read for meaning by using this emergent literacy skill.

**Keywords:** Autism Spectrum Disorders, emergent literacy, iPad, application design.

## 2 Research and Design

We started from reviewing literature to understand the cognitive deficiencies associated with ASD and determining instructional needs and target zones for instruction. The cognitive deficits revealed an interruption in the ability to process information. Autism makes attention and perception difficult to achieve and directly affects learning. (Rasche and Qian 2012) We chose to use the iPad for instruction because it helps to focus attention and increase time on task to enhance learning. (Putnam and Chong 2008)

Our main design goal is to help children with ASD to read for meaning. The focus of labeling actual objects in context using an environment where many of the objects were readily understood was important. With this in mind, we decided to design the application for the home environment. Figure 1(a) demonstrates a persona of the initial targeted audience of children with ASD. After reviewing the design mockup with professionals, we realized that it could actually be built as an inclusive design that fits the widest possible audience - children with varying types of learning disabilities and typical development preschoolers.

Figure 1(b) shows the two instructional methods in Literacy LABELS. The first method is the novel approach of using the iPad camera as a scanner to allow for a visual and audio response for all the printed labels. By interpreting the context of the actual objects, it is easier for the children to build up the understanding of the text meaning. The second method is playing the game to reinforce the skill being taught with the direct instruction of the physical labels. We propose that the combination of using these two learning methods will help to strengthen the association between the orthography and the object.

Usability considerations for the interface had to meet the nature of our user group. For example, we placed teacher controls in a secure locked location to prevent the child from selecting these buttons. Another adjustment was to lock the screen while the prompt is being read to discourage the child from randomly making selections before hearing the instructions.

As displayed in Figure 1(c), we created a mockup of the system and conducted a series of formative evaluations with facilitators at Purdue University's Speech Clinic. Based on the results, we made changes and refined the application's structural design and graphics as illustrated in Figure 1(d).

Our prototype of the QR code decoder and one room of the application are ready for a summative evaluation with the user groups. As part of the iterative process, we will revise the system after the evaluation and then release it for final coding.

## References

Putnam, C., and L. Chong. 2008. "Software and Technologies Designed for People with Autism: What Do Users Want?" In *Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility*, 3–10.

Randi, J., T. Newman, and E. L Grigorenko. 2010. "Teaching Children with Autism to Read for Meaning: Challenges and Possibilities." *Journal of Autism and Developmental Disorders* 40 (7): 890–902.

Rasche, N., and C.Z. Qian. 2012. "Work in Progress: Application Design on Touch Screen Mobile Computers (TSMC) to Improve Autism Instruction." In *Frontiers in Education Conference (FIE), 2012.*

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# CHAPTER 1. INTRODUCTION

Do you know someone with autism? Since the CDC approximates that 1 in 88 American children are on the autism spectrum (CDC 2012), chances are that you do. There is an estimated 10-17% annual growth in the occurrence of diagnosis of children with autism since 2003 (Autism Society 2011). This significant increase in the prevalence of ASD has led to an increase in research of related instructional techniques for those affected. Currently, there are a wide range of assistive technology devices available that can be implemented by teachers, parents, and/or therapists. These items range from the low-level visual symbol cards to the high-level computer assisted instruction (CAI) devices. Among the many assistive technology options, CAI provides the educational advantage of providing consistent and predictable feedback that can be repeated many times to reinforce skills (Morris, Kirschbaum, and Picard 2010). For such use, touch screen mobile computers (TSMC, such as the iPad) stand out because of their potential price affordance, accessibility, and usability. My research topic of developing new applications for autism therapy on the iPad was inspired by a collaborative design experience with Purdue University's EPICS (Engineering Projects in Community Service) program in 2011. The team I participated in was developing a suite of iPad applications to be utilized as communication aids for

children with autism and other special needs (EPICS_GLASS - Assistive Technology 2012). The experience of working with these applications inspired the two main objectives in this thesis. First is to develop a TSMC application based on related literature to improve the current learning condition of those with ASD. Second is the development of a Definition Outline for Collaboration (DOC) for the *define* phase of the design strategy cycle that can be shared with design society to encourage further application design development for children with ASD. I worked toward these two objectives through conducting literature reviews upon the topic, synthesizing theories learned, detailing foundation work, creating the application design, and reviewing the *define* phase of the design strategy cycle to create the DOC.

CHAPTER 2 is dedicated to review, interpret, and summarize my literature review upon ASD and what children with autism most need to improve their current learning condition. To find an area of design focus for the application it was necessary to understand the user and all the zones for possible instructional need that could be supported on the TSMC. The user research phase was conducted to understand the cognitive deficiencies associated with ASD and the impairments that are presented by the learner with autism. Next the research was to understand the instructional learning processes of the child with autism. This research facilitated the awareness of the learning styles that would best support learning for this user group on TSMC. Lastly, research was done into literacy and ASD. Since the area of focus is literacy, it was important to

understand the current condition of children with ASD in relationship to literacy. All of this user research was compiled to create a complete picture of their needs and goals based on understanding autism, their learning styles, their literacy development, and the use of the TSMC as an instructional tool.

Based on the insights synthesized from the literature review, I introduce my models based on this information CHAPTER 3. In this chapter, I include a model of ASD impairments for zones of instructional need, a diagram of the interruption of information processing, a map of how the emergent literacy skill of vocabulary can relate to the user's needs, and a summary of the strengths and weaknesses of TSMC for autism instruction. The model of the possible zones of instruction for autism instruction was created from the list of impairments identified during the literature review (Figure 3.1). The zones of instruction identified a need in the area of communication, specifically literacy and reading comprehension development. The interruption in the processing of information model (Figure 3.2) in the learner with autism is illustrated based on the research done into attention impairments with ASD and the information processing model presented by Wickens (Figure 2.3). This illustrates the difficulties that the child with ASD faces in the area of learning and retention. This research on information processing highlights strengths in the TSMC because it helps to direct focused attention. By understanding the user's difficulty with reading comprehension, the idea of using emergent literacy skills to improve this condition is detailed. The knowledge of literacy and ASD made it possible to create a diagram of emergent literacy skills

with a focus on vocabulary to improve comprehension (Figure 2.4). By expanding on the symbol based communication that is currently being taught for many non-verbal children with ASD using the Picture Exchange Communication System (PECS), the idea of using labeling with the emphasis on the orthography (written word) over the symbol was developed and illustrated (Figure 3.5). The last discussion in chapter 3 deals with a summary of the TSMC interaction strengths and weaknesses in relation to being an effective tool for different ASD impairments (Figure 3.6 and Figure 3.7). By reviewing the strengths and weakness of the TSMC and the software requirements for this particular user group, I was able to create a clearer understanding of how to use the TSMC as an effective tool for instruction.

My foundation work with the EPICS/ IPAAC suite of applications (CHAPTER 4) served as a skill-preparation and pilot exploration for my study. This section details my involvement with the interaction design development with Purdue's EPICS (Engineering Projects in Community Service) department on the IPAAC (Interactive Programmable Alternative and Augmentative Communication) suite of applications for students with special needs. These applications were designed with the community partners of GLASS (Greater Lafayette Area Special Services) and Dr. Oliver Wendt (Assistant Professor, Purdue University). The goal was to create a suite of applications that would assist the specific impairments of the students at the high school level that have severe autism or other developmental disabilities. The application *SPEAK all!* is specifically

described. This application was designed from the symbol based card system to help develop functional communication in non-verbal users.

CHAPTER 5 is focused on the creation process of an application design based on this investigation – *Literacy Labels*. This portion of this paper will detail the first goal of this thesis, the design strategy cycle for a new application based on research methods. The development of the new application was established based on the knowledge learned from the literature review and the direct learning experience gained during the development of the EPICS suite of applications. There are four stages of the design strategy cycle that will be detailed for *Literacy Labels*. The first stage, *define*, will summarize the research to construct a clear picture of the user persona and the goals for the application. All of this information will be derived from the literature review, methodology, and new studies. The second stage, *design*, will include the ideation sketches, the formation of use case scenarios, and the development of wireframes for the application. *Develop* is the third stage of the design strategy cycle; it will contain the creation and evaluation of the mockup, the finalizing of the interaction design, and the creation of the visual design for the application in preparation for prototype testing. The last step in the creation of the application is the preparation needed to *deploy* it for software coding. This phase details the compiling of the necessary items and information to implement the transfer of the application to the software developers. This would include the finalization of the visual design layouts and the design document. These four stages of

application design strategy detail the steps in the process that lead to the creation of the application based on the goals set forth by the research.

CHAPTER 6 summarizes the Definition Outline for Collaboration (DOC) of TSMC application design to improve educational resources for children with ASD. The second goal of this thesis will be explained in this section. It was to create an interaction design DOC to explore the potential, boundaries, and directions of developing iPad applications for autism therapy within the design community. The objective is to create a bridge between the research community and the design community by creating this outline to communicate design possibilities for application development. By following this DOC, it will be easier for the educator, facilitator, parent or anyone for that matter, to convey their ideas for applications to a designer. The best way to show the development of this DOC was to make it for two common types of educational application design. The first type is creating an application that will be based on a proven direct instruction methodology. For this example, my experience with the EPICS development of the mobile application *SPEAK all!* is used. This application design was created based on the symbol based card system of non-verbal communication (Figure 3.3). The second type is creating an application based on research that identifies a user need that can be supported with a mobile application. For this example, the development of the application *Literacy Labels* is referenced. Thus, *SPEAKall!* and *Literacy Labels* will be the examples of the two types of approaches to application design development for the DOC that can be used to

begin the collaboration between the educator and designer to enhance the quantity and quality of applications for those with ASD.

In CHAPTER 7 the preliminary evaluations are summarized. It includes a list of structural changes that were made to the application design based on the feedback from the focus group and interviews. As the application development continues, so does the need to evaluate the strategy and create a plan for future changes and development. The conclusion in CHAPTER 8 reviews the process of this thesis and the areas for further growth. This will include setting up more evaluations for *Literacy Labels* and the DOC, researching new ways of scanning labels, and a possible expansion of the application.

# CHAPTER 2. LITERATURE REVIEW

My literature review will serve to identify user needs and make educated design decisions possible. As a user centered design, my research was conducted from the three perspectives of the impairments, the learning styles, and the development of literacy skills for children with ASD.

## 2.1 What is Autism?

Autism spectrum disorders (ASD) are a group of developmental disabilities characterized by atypical development in socialization, communication, and behavior/attention (Pellicano 2010; Rice 2009; Schreibman 2005).The challenge is that ASD has no proven cause or cure. What is distinctive to those with ASD is the wide range of impairments, their varying capacity, and the unique strengths that be exhibited alongside these deficiencies. Stephen Shore once said that “if you’ve met one person with autism - you’ve have met one person with autism.” Each person with ASD is unique, so a perfect treatment does not exist for all. To design an application for a user group, the typical first step is to understand the users’ condition and their requirements. I believe that selecting an application design course that will be most beneficial for children with autism should be made upon understanding the disorder and detailing all the areas for needed instruction. Two ways to achieve this are with direct observation of children with

autism and through literature reviews. The direct observations are explained in section 4.1 on foundation work with the EPICS program. A review of what was necessary to understand the disorder and the user needs is detailed by evaluating the ASD cognitive deficits, functional deficiencies, and impairments.

### 2.1.1 Deficits and Impairments

Autism specific cognitive deficits constructed an enigma instead of an explicit list of impairments - every child diagnosed with autism will have a wide range of deficiencies at many different capacities. According to Schreibman in his (2005) book, *The Science and the Fiction of Autism*, there are four criteria that must be met in order to label a core deficit for a disorder.

- Specificity: The deficit must have specificity to autism. Specificity means that this disability is specific to autism and is not found in non-disabled persons or in those with other disorders.
- Universality: It has to have universality to all individuals with autism. This states that all diagnosed with autism will have this deficit.
- Persistence: The deficit has to show persistence by continuing throughout the developmental process.
- Precedence: Lastly, there must be precedence to the deficit, meaning it begins early in development and does not suddenly appear later in development.

Schreibman (2005) states that there are no core cognitive deficits specific to autism that fit any of these requirements. Therefore the cognitive deficits associated with autism are presented as functional developmental disabilities

versus clinical disabilities. This is because clinical disabilities must be associated with a core deficit that is common to all who have the disorder, such as lowered IQ in individuals with Down Syndrome. As a result, there is a vast list of functional disabilities, or impairments related to ASD, that are not specific to all individuals diagnosed with the disorder. My goal of the literature review is to create a list to summarize the impairments that are tied to the cognitive deficits associated with ASD to create a detailed register that can be considered zones for therapy instruction. I started by summarizing the cognitive deficits that may be apparent in many, but not all of the individuals with ASD.

#### 2.1.1.1 Cognitive Deficits

There are three general areas of cognitive deficits for children with ASD: theory of mind, executive function, and central coherence. These three deficits contribute to the impairments that are commonly exhibited by the child with autism: communication, social skills and attention/interest.

**Theory of Mind**

Theory of Mind (ToM) can be described as an ability to understand the mental state of oneself and/or others (Pellicano 2010; Fletcher-Watson and McConachie 2010; Schlinger Jr 2010). It has been noted that children with autism appear to live in their own private world. This characteristic is directly related to ToM because children with autism have difficulty in understanding the perspective of others. Therefore, ToM is a cognitive deficit associated with ASD that can be considered one of the causes of communication and social skill delays. Target

zones of instruction associated with ToM would include communication skills of figurative language, verbal and non-verbal language, and conversation skills. It also can include the social skills of eye contact, identifying emotion, affect, imitation, pretend play, and joint attention.

### Executive Function

Executive Function (EF) is the ability to make planning strategies to reach goals and having the flexibility to modify goals as necessary (Pellicano 2010; Ozonoff et al. 1994; Happé 1999). EF deficits are noted in ASD as the characteristic to strict coherence to routines and patterns. Instructional zones for EF would include the components of planning skills, problem-solving strategies, memory games, and behavioral control.

### Central Coherence

Central Coherence (CC) can be described as the ability to process information to achieve a whole and coherent meaning. Children with ASD show exceptional skill at processing details, but the capacity to grasp inferred meaning in language and social settings is difficult for them (Pellicano 2010; Happé 1999). The skill of joint attention is evident as there is a lack of awareness of the feelings of others. Instructional areas to for CC could include joint attention, inhibitory control, emotional processes, affect, and comprehension.

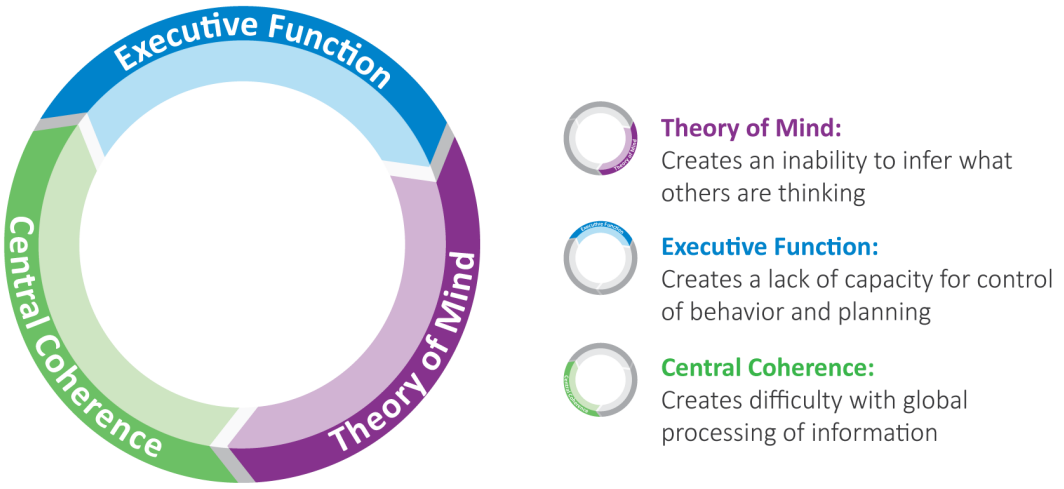


Figure 2.1 Diagram of ASD Cognitive Deficits

These cognitive deficits will exhibit themselves in the functional impairments that are apparent in those with ASD. Understanding these deficiencies will help to create a list of instructional need. Although, it is important to note that there is a connection between these deficits that can cause an increase or decrease in the capacity of the related functional impairments. In other words, these deficits are linked, overlapped, and can influence each other directly. The diagram shows arrows in between the three areas of deficits because any one can have more emphasis, less emphasis or affect the other areas. To understand it further the specific areas of functional impairments related with these deficits areas is explored.

2.1.1.2 Functional Impairments

The three areas of deficit lead to the three most common areas of functional impairments: communication, social skills and attention/interest. As stated earlier, the cognitive deficits associated with ASD will be varied among individuals, and

therefore, so will the impairments. The section on communication impairments will entail all areas of functional communication, including literacy. Social skills will be discussed as this is an area of impairment that is apparent in most with ASD. And finally, the discussion on attention/interest will entail those areas and how they can affect learning.

### Communication Impairments

Communication delays are one of the standard indicators of autism prognosis. This impairment is apparent in most with ASD and is an area of impairment that makes difficulties in social skills even more apparent. Those with ASD that do develop verbal communication skills find that it is often delayed and/or deviant from normal typical development. Since children with autism have different deficiencies, the ability to communicate varies. Children who have prolonged communication delays or complete lack of functional communication, will take longer to develop functional communication and some may never develop communication (Light et al. 1998). Specific communication instruction for non-verbal children with ASD is often situation specific and has not led to spontaneous language development (Volkmar 1998). There has been success in teaching non-verbal children with autism communication with the support of imagery such as symbols. For example, the Picture Exchange Communication System (PECS) (Boesch et al. 2013) and other AAC devices have achieved success in verbal communication development (see section 3.3 for more information about PECS). Some of the impairments associated with communication will include verbal communication, non-verbal communication,

reading, figurative language and conversation skills. In the area of reading and literacy, children with autism have difficulties with comprehension. According to Nation, et al.(2006), “no matter where children fall on the spectrum, children with ASD generally demonstrate well-developed word recognition skills, but their reading comprehension is severely impaired.” An extreme profile of word recognition skills developing in advance of reading comprehension is called hyperlexia (Grigorenko, Klin, and Volkmar 2003; Grigorenko et al. 2002). A detailed explanation of literacy and ASD will be discussed in 2.3 Understanding Literacy Instruction and Autism.

### Impairments in Social Behaviors

According to White, et al.(2007) state that “the social reciprocity deficits are a core feature of the autism spectrum disorders.” “Socialization deficits are a major source of impairment regardless of cognitive or language ability for individuals with ASD (Carter et al. 2005)” Social development is impaired and it is directly linked to communication impairments. Children will exhibit impairments in social pragmatics, speech inflection, expressing emotions, and non-literal language skills. These deficiencies in the area of social skills can cause mood and anxiety problems later in development (Myles et al. 1993). As mentioned earlier in the section related to the cognitive deficit of Theory of Mind, those with ASD tend to live in their own private world. This deficit leads to difficulties in performing adequate social skills. Interestingly, according to White et al. this is not because of a lack of social interest, but a lack of social skills (White, Keonig, and Scahill 2007). There are many intervention techniques for social skill development and

most involve direct instruction. There have been a few social training applications developed for TSMC, but the results have been varied. "The results of these studies indicated that Computer Based Interventions (CBI's) effect on social and emotional skills was mixed, with the majority of studies reporting unacceptable outcomes following intervention (Ramdoss et al. 2012)." Since most of the social skills that need to be taught require interaction between individuals, it is understandable that TSMC are not as desirable compared to direct behavioral instruction for social skill development.

### Attention Deficiencies

Impairments related to attention are common in those with ASD. Children can exhibit overselective attention, lack of focused attention and difficulties dividing attention. Overselective attention can be compared to an obsessive attention to one specific piece of information versus the entire group of information (Liss et al. 2006). This type of attention can interfere with learning because redirecting their attention to other instructional topics is challenging. Basically, overselective attention can distract the child from the main purpose of the learning opportunities. The opposite of overselective attention would be an inability to focus attention. Somewhat like the social skill deficiency of lack of social awareness, a lack of attention will cause the failure of learning. As discussed in further detail in section 3.2, the deficits associated with autism can block the processing of information that leads to learning. Finding techniques to improve attention will help to improve learning and time on task. The TSMC have shown marked improvements in focused attention for children with autism.

***"Prior to using the iPads, it was very difficult to get any of my students to engage in an activity for more than five to 10 minutes. Now I can use a program on the iPad to help them learn in an interactive way, without having to micromanage behavior. My students are making an exciting and positive association with learning (Lernihan 2012)."***

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Figure 2.2 diagrams the three functional impairments along with their basic definition. These three functional impairments of communication, social skills and attention/interest combine with the cognitive deficits of ToM, CC, and EF to cause deficiencies in the child with ASD that affect their capabilities of learning and processing information.

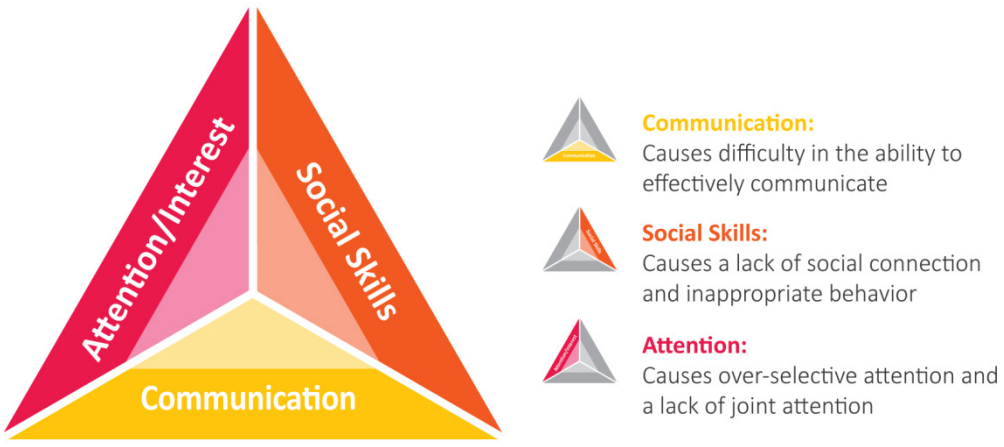


Figure 2.2 Diagram of Functional Impairments

## 2.2 Autism's Effects on Learning

There are many learning challenges for those with ASD, but there are learning styles that can help enhance the learning process and retention of new skills. In this section, two questions related to learning and children with autism are discussed. The first is why is information processing difficult? The second is what instructional methods are best suited to help children with ASD learn?

### 2.2.1 Difficulties in Information Processing

The cognitive deficits associated with autism create a learning block for many children with autism. Figure 2.3 below by Hollands and Wickens (1999), show how learning is heavily dependent on the ability to focus attention and perception on new information. This is necessary to process information at a level that makes it possible to be considered applied to working memory and therefore retrievable for later use. Thus, learned information would require information to be stored and later recovered to apply this new information at a later time. Wickens (1999) discusses three modes of attention; selective, focused and divided.

> **"Selective attention chooses what to process in the environment, focused attention characterizes the efforts to sustain processing of those elements while avoiding distraction from others, and divided attention characterizes the ability to process more than one attribute or element of the environment at a given time."**

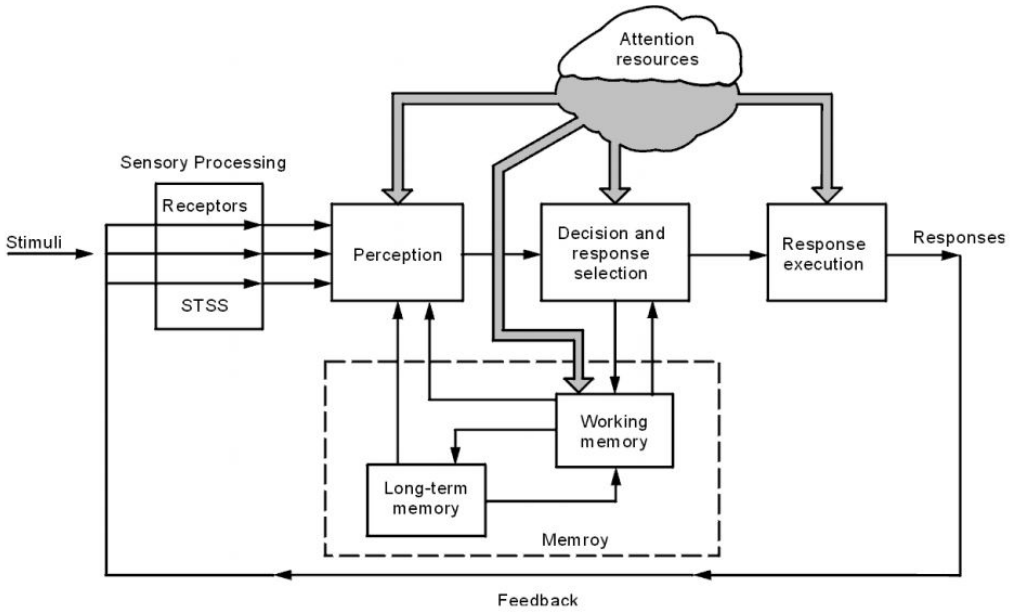


Figure 2.3 General qualitative model of the human information processor (Wickens, 1992)

When considering the types and levels of attention required when learning new information, it is evident that the ASD impairments will make this process exceedingly difficult. Therefore, the cognitive deficits associated with autism cause an interruption in the processing of information by making it difficult for the learner with autism to focus attention resources on stimuli to learn new information.

### 2.2.2 Learning Style and Instructional Methods

Research into ASD instructional methods helps to answer the second question of what instructional methods are best suited to help children with ASD learn. This required the need to understand how children with autism learn. The first, and most commonly mentioned learning style, is that children with ASD tend to be

visual learners who benefit from the use of imagery such as pictures and symbols (Quill 1997). Tempel Grandin, who has autism, says that “most people in the so-called normal world think in words, but thinking in language and words is alien to me. I think totally in pictures (Kathleen Ann Quill and Grandin 1995).” Another common learning style is that children with autism prefer consistent routines and structure. One of the many strengths of instruction on the TSMC is consistent feedback, structure and repetition (Murray and Olcese 2011). Based on these learning styles, I started to search for research into effective instructional methods. Peter Westwood (2007) stated that “the main priority in teaching children with intellectual disability is to make the curriculum reality-based and relevant.” He mentions that using situations that are interesting, engaging and understood by the child is essential. It is also important to stress the principle of learning by doing. Simple and or explicit instruction is recommended, this includes teacher modeling, many opportunities for repetition, and immediate feedback. In order to produce an effective learning environment with the application, it is important to consider all of these learning styles and when possible create opportunities for a variety of instructional methods that follow these principles. The knowledge learned about the instructional methods in this section is applied to the area of design focus which is literacy. Impairments in literacy in the learner with autism are discussed in the next section.

## 2.3 Understanding Literacy Instruction and Autism

Based on the research, the application design area of focus has been identified as communication, specifically, literacy and comprehension. AAC devices have translated well to the iPad to help the learners on the spectrum with severe communication delays. Applications such as *iConverse* and *SPEAK all!* have successfully enhanced communication for non-verbal users with ASD (Yee 2012; Izzo and Bauer 2013). More information on communication applications is discussed in 3.3 Literacy and ASD. Since this has been successfully documented as a strong area of instructional success on the iPad, I wanted to further research areas for instructional need related to communication beyond verbal and non-verbal communication. One such related area is literacy. Literacy is a broad term relating to the ability to read and to write. Children with ASD have difficulty in the literacy area of comprehension (Nation et al. 2006) and the idea of improving this condition was explored. One area that can help with reading for meaning is the emergent literacy skill of vocabulary. As children prepare to read, they must understand that all words have meaning. Concurrently, they should understand that by putting words together they will create a complete meaning. Emergent literacy covers the skills necessary for reading and writing before functional reading and writing occur.

Emergent literacy was introduced by Marie Clay in 1966 as the concept of how young children interact with books before starting to read and write (Clay 1966). There are six basic components; print motivation, vocabulary, print awareness,

narrative skills, letter knowledge, and phonological awareness. These basic skills are often evaluated with young children to determine their reading readiness or even their likelihood for reading success (Lanter et al. 2012). One area of emergent literacy that could possibly help the child with ASD to improve comprehension and could translate well to the TSMC is in the area of vocabulary development by using the skill of labeling objects. Broadening vocabulary knowledge beyond basic word recognition is an essential skill for reading comprehension. Figure 2.4 illustrates emergent literacy skills and how they pertain to the application *Literacy Labels*.

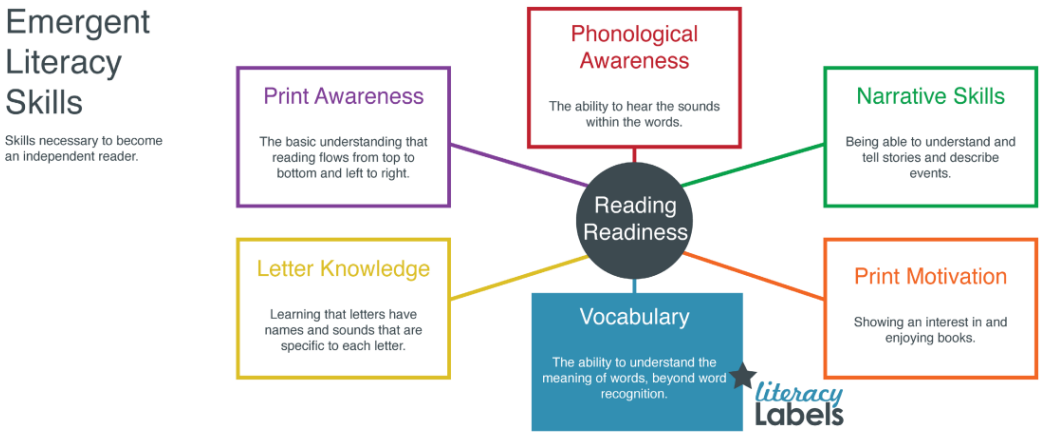


Figure 2.4 Emergent literacy skills and *Literacy Labels*

After conducting this literature review, I applied this knowledge to synthesis the information into new models. These models along with my foundation work, made it possible to design the application for the most ideal user experience.

# CHAPTER 3. MODELS SYNTHESIZED FROM RESEARCH

## 3.1 Creation of Zones of Instructional Opportunity

Detailing the impairments associated with autism was helpful to identify an instruction area that would benefit the child and be successfully implemented on the TSMC. Figure 3.1 below combines the cognitive deficits and the functional impairments to create a list of the zones of instructional opportunity (Rasche and Qian 2012).

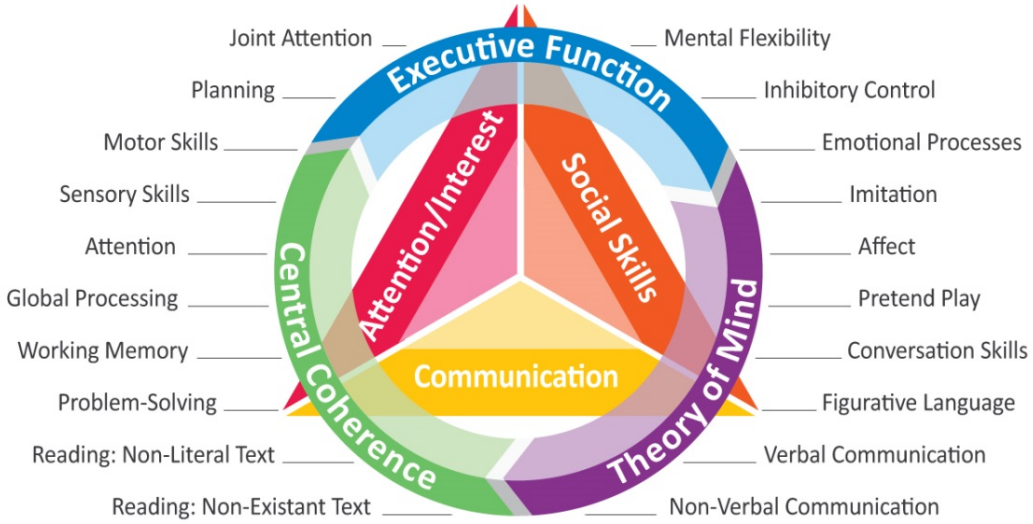


Figure 3.1 Diagram of zones of instructional opportunity

This information benefits the design of the application by enhancing strategies to improve instruction based on research into the disorder. These zones of instruction outline a clear and validated structure of the specific instructional needs of the user. The next step is to visualize the learning process for those with ASD. It is apparent that the deficits and impairments associated with autism will affect the users learning style. Therefore, the mode of administering the instruction must be founded on understanding these learning styles and assessing best practices for instruction through TSMC.

## 3.2 Information Processing

The deficits related to autism make attention and perception difficult to achieve and directly affect learning (Rasche and Qian 2012). Based on the literature review of the General qualitative model of the human information processor (Wickens, 1992), the cognitive deficits associated with autism interrupt the processing of information to memory (Figure 3.2). This interruption reduces the amount of input translated to memory that can be later accessed to make appropriate decisions. This information is significant in the argument for using TSMC in autism instruction because they help to focus attention in children with autism (Lernihan 2012).

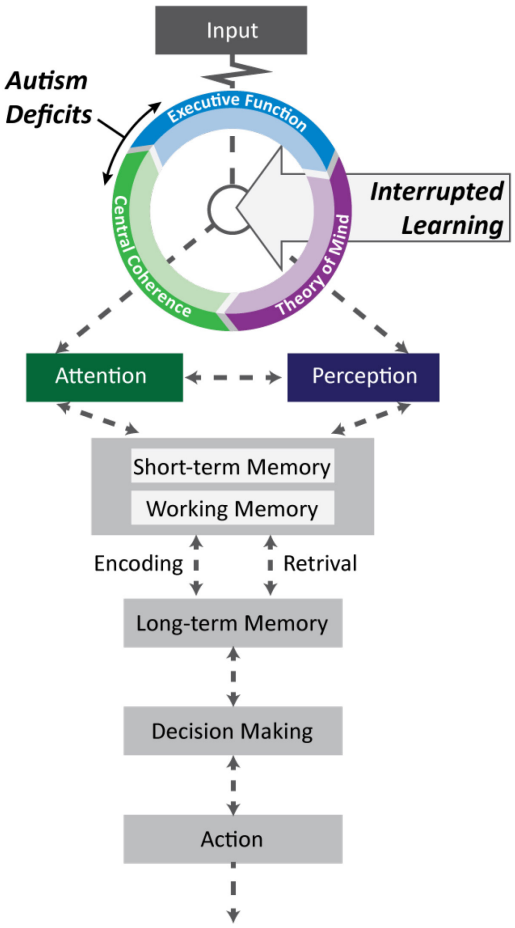


Figure 3.2. Diagram of information processing interruption

## 3.3 Literacy and ASD

There is a common tendency among those with ASD of being able to read by decoding before an understanding of comprehension is established. Hyperlexia is a type of reading skill that is focused on decoding. Hyperlexia is categorized as superior decoding skill beyond expected for age level that is combined with poor comprehension and below normal verbal communication (Grigorenko, Klin, and Volkmar 2003). According to Newman et al., this reading ability can occur before they develop any functional verbal communication.

> ***"It was found that children with ASD decode words by relying on the same phonological and orthographic mapping processes as typical readers. Unlike in typically developing readers, however, the more abstract skills of reading comprehension do not develop along with their word recognition skills. (Newman et al., 2007)"***

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Knowing that this is a common impairment for children with ASD, the question proposed for this application research design is: can teaching the emergent literacy skill of labeling with the iPad before reading and writing skills develop help to improve the comprehension skills of children with ASD? The application design will focus on labeling objects in a well-known environment that will support AAC skills. This instruction should run concurrently with verbal communication instruction to best improve vocabulary with the comprehension of the words while developing decoding skills. In the ASD design domain, understanding the development of verbal communication for the child with autism will help to identify if they are ready to start the emergent literacy instruction with a TSMC application focused on teaching labels.

Many children with ASD learn functional communication with the PECS (Figure 3.3) that is a pictorial symbol based system that was developed for children with social-communication deficits (Frost and Bondy 2002). The system uses basic behavioral principles and techniques to teach children functional communication

by using cards with symbols to represent the meaning instead of using verbal words. Those who use the PECS system usually start with no functional communication and the system has proven effective for the child to communicate their needs. The PECS system does not usually include verbal communication; in fact it is typically used as a communication tool for those who are non-verbal. The definitive goal of this communication program is to facilitate the beginning of functional non-verbal communication. Depending on the learner's level of disability, this goal may or may not be attainable. PECS based applications have proved successful in their transition to the TSMC as a supplemental tool to reinforce skills taught with symbol based systems or even replace them. It has also been documented as a successful tool in attainment of verbal communication with non-verbal ASD learners (Wendt 2012). Applications such as *SPEAK all!* and *Proloquo*, teach language acquisition using the cards as an Augmented Alternative Communication (AAC) device on the iPad for children with autism. Since most children with ASD are visual learners, this system helps them to identify the symbol with its meaning, the same way the physical PECS cards do. PECS enforces the teaching of symbols that relate to real objects or needs within the context of use, such as child creates "I want drink" in the sentence strip and the child gets a drink (Figure 3.4). This one on one language development had been largely done by a facilitator and within the realm of a real world experience (snack, playtime, etc.) as it is occurring. As for the application design, the question is how can this literal context translate to a larger vocabulary base?


Figure 3.3 PECS binder ("Pyramid Educational Consultants, Inc" 2013) and
Figure 3.4 *SPEAK all!* iPad ("EPICS_GLASS - Assistive Technology" 2012)

The capacity to expand the meaning of words and to expand the vocabulary base will assist in the preparation for reading. To improve the quantity of vocabulary acquisition during the pivotal window of language intervention, the instructional teaching of labeling should start when the child has developed a base of functional communication. The PECS based systems teaches the skill of symbol recognition and meaning to bridge toward functional communication. The labels in *Literacy Labels* show the orthography of the word and meaning in context during vocabulary instruction (Figure 3.5).

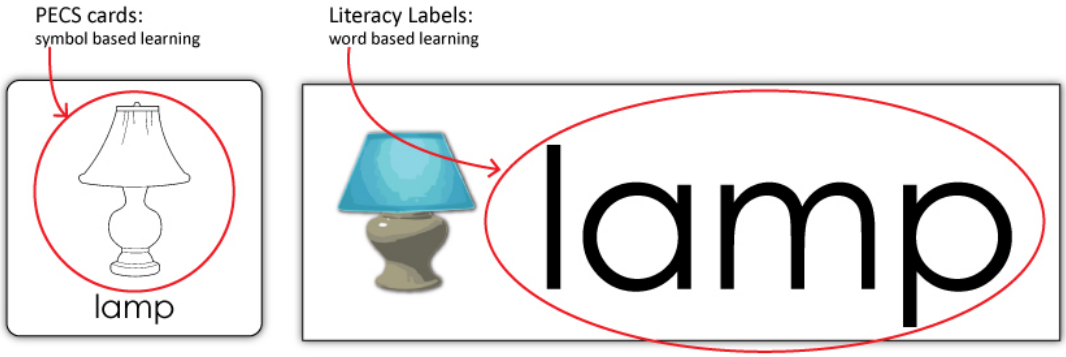


Figure 3.5 Comparison of PECS card and label for *Literacy Labels*.

For a child, using this vocabulary based teaching in the context of a familiar environment should help with the association of the new vocabulary to real world experiences. Teaching the concept of the written word in real world context is very important for children with autism who are visual learners and benefit from real world experiences. Using labels for objects can also be an effective tool for teachers and parents to convey to the child that all objects have a verbal name and written name. For example, putting a label on a lamp and pointing to it when near or using it will translate the permanence of that object's association to its orthography, or written word. The real world understanding of placing these labels on the actual object can help to make this translation easier for the child with autism.

This research into literacy instruction for children with ASD suggested several principles for the instruction application design (Lanter et al. 2012; Justice and Pence 2004; Hurewitz and Beals 2008).

- Visual emphasis: Connect words with visual representations, ideally with actual physical objects.
- Dual instructional techniques: Use a combination of instructional techniques, such as direct instruction and computer-assisted instruction.
- Safe environment: Set up a comfortable and familiar learning environment, preferably in their home or their classroom.

- Combine vocabulary with communication: Combine vocabulary skill instruction with verbal communication instruction to develop their abilities in both areas.
- Provide a reward system: Use some type of reward system to encourage engagement with the application and to reinforce correct behavior.

This pedagogy will need to be followed to improve learning and retention. The TSMC has strengths and weaknesses that need to be considered to effectively design the application to support these goals. Using the TSMC as a teaching tool to support direct instruction requires the identification of the features to emphasize and the features to avoid. These features for the TSMC and the characteristics of software application design for children with autism are discussed in the next section.

## 3.4 TSMC Strengths and Weaknesses

Three main aspects of assessment were identified for the TSMC – physical attributes, interaction, and accessibility.

### Physical Attributes

The TSMC have strengths in the area of being portable, light weight, easy to use, and have high quality screens. The negative physical attribute is that they can be seen as a novelty (Shah 2011), the screen can be fragile, and it can be difficult to hear in a loud environment. To avoid these problems, it will be necessary to focus time spent on the TSMC as learning time, and to provide a sturdy case that, preferably, has a speaker.

## Interaction

Some of the positive interaction attributes in mobile application design are improved attention, customizable features, repetition of skills, multi-skill instruction, multi-sensory skills, predictability/sameness, one-on-one structured learning and immediate feedback. The implementation of customizable features and multi-skill instruction allows for modifications based on the individual needs of the child. While improved attention, predictability, and immediate feedback are obvious strengths that should be emphasized in the application design (Putnam and Chong 2008). In comparison to the other Augmentative Alternative Communication (AAC) devices, the TSMC provides teachers and/or facilitators with less preparation ahead of instruction and less materials needed for implementation (Flores et al. 2012; Shah 2011). Another plus of the TSMC software applications is that they offer the child a sense of independence as the control is shifted to them, or at least perceived by the child as such. It is important to note that TSMC can further detach the child from social interaction. When using any computer aided instruction (CAI) device, it can reduce interaction with peers, instructors and/or family. The time spent on the TSMC must be focused and controlled. The TSMC is one of the many types of instructional teaching methods. It works well as a supplement to help reinforce skills being taught by direct instruction. It is also important to avoid functions that may distract from the learning, such as games and confusing organization of the apps.

## Accessibility

While choosing the platform to develop a learning tool for children with ASD, the TSMC are much more accessible than many other AAC devices. The TSMC are considerably cheaper and they are easy to obtain. The average cost of an iPad is under $500 dollars, while a *ProxTalker* AAC device can cost over $2000 ("ProxTalker.com" 2013). The TSMC also provide the student the opportunity for instruction reinforcement at home because of mobility. Considering the durability, TSMC are comparably fragile. Most AAC devices, like the *ProxTalker*, are designed to withstand the usability of a child with autism that could include hitting, dropping, saliva, etc. The TSMC are not designed for these situations. To amend such an issue, a high quality case must be used that will be well padded, water proof, easy to carry, and, ideally, have a speaker (Shah 2011; "Longwood Alumna Uses Ipads to Help Students with Autism" 2012; Flores et al. 2012; Putnam and Chong 2008). All of the research on the strengths and weakness of the TSMC make it possible to focus on the good and attempt to eliminate the bad before design ideation begins. Below is an illustration of areas to emphasize and the areas to avoid for the TSMC.

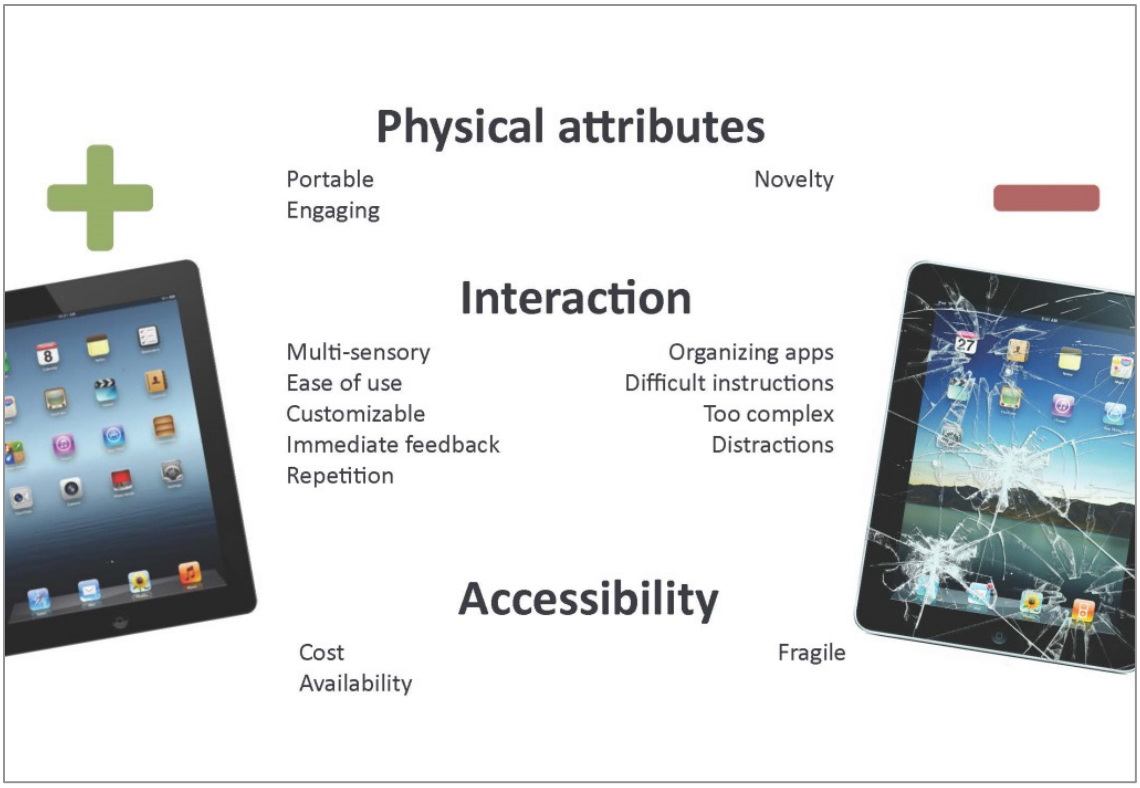


Figure 3.6 Illustration of TSMC strengths and weaknesses

## 3.5 User Requirements for ASD Application Design

Application design for autism education will require a set of requirements to improve the probability of successful learning. There are many applications marketed for children with ASD. Literature review on software for skill instruction for children with autism related to the strengths of the software interaction design and to the effectiveness of learning instruction based on the deficiencies associated with ASD is discussed below. These two approaches to the literature review helped to create a list of requirements necessary for the application design.

**Effective Skill Instruction on the TSMC**

Upon reviewing the results of research on existing applications for learners with autism, I found that the area of communication impairment would benefit from mobile applications. Language development intervention, specifically communication, showed marked success when it was supported on a TSMC. Communication applications such as *iConverse* ("iConverse" 2013), *Proloquo2go* ("Proloquo2Go" 2013) and *SPEAK all!* ("IPAAC EPICS" 2013) have shown success in assisting persons with communication difficulties through the iPad (Yee 2012). The simplicity of large cards with symbols for basic needs is used in *SPEAK all!* and in *iConverse*. The cards provide auditory and visual responses that support communication development. These two applications allow for customization by adding cards based on the unique needs of the user. This approach suggested by these applications is significant for the unique variety of impairments for each child with autism. Applications like *Proloquo2go* are more complex systems with larger vocabularies that behave as a text to speech program for higher functioning non-verbal individuals with ASD and other non-verbal disorders (Yee 2012).

As stated earlier, research into current applications on the market in the area of social skill instruction on the TSMC has had different levels of success. Some professionals fear that teaching social skills on the iPad disregards the complexities of social interactions and can further isolate the users (Putnam and

Chong 2008). It appears that this skill may be best taught with one on one behavioral therapy approaches.

### Software Interaction Design Considerations

Some of the strengths of the software interaction and design for children with autism have been mentioned. One specific software design considerations, that it must have, is easy instructions that have only one signal at a time to reduce distractions. By targeting specific skills with immediate feedback with a reward system, applications can be successful tools for instruction. One can also reduce distractions by taking advantage of the accessibility feature in iOS 6 or later (Johnson 2013). The guided access feature allows for the facilitator to lock the application so that you cannot press the home button, or exit button, to leave without having the pass code. There is another strategy to disable certain parts of the screen within the application. These features are extremely effective for customizing pre-existing applications to match user's needs and focus them on tasks. The application design should take advantage of the interaction strengths by making the accessibility limited to skill instruction, and improve information processing by being engaging and enjoyable.

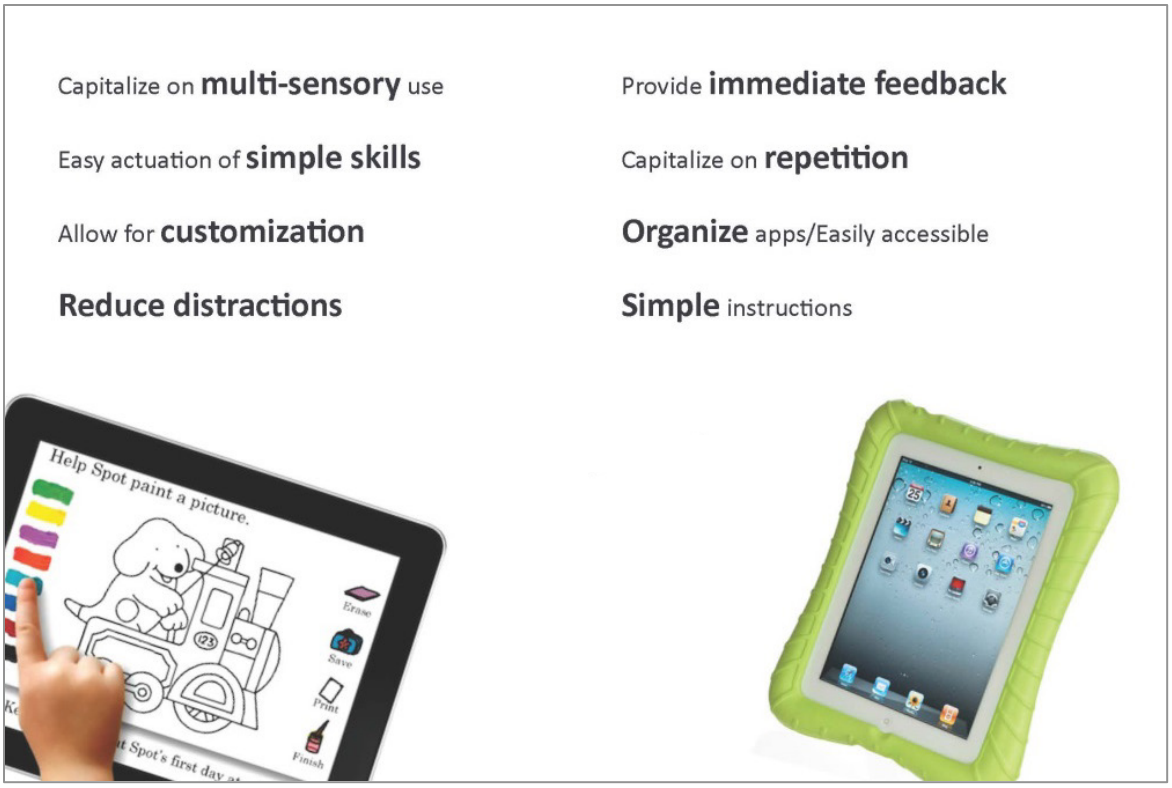


Figure 3.7 Illustration of software design considerations

After reviewing TSMC devices to understand their strengths and examining the effectiveness of available applications for students with autism, the next step is to figure out the plan, methods and lessons of the application design. My foundation work experience in Purdue's EPICS department provided many references and knowledge for my journey.

# CHAPTER 4. FOUNDATION WORK: EPICS PROJECT

This thesis research was inspired by my experience with Purdue University's EPICS (Engineering Projects in Community Service) GLASS (Greater Lafayette Area Special Services) IPAAC (Interactive, Programmable, and Alternative Augmentative Communication) program. This project assisted in my preparation to develop an application for children with ASD. A summary of the IPAAC program is described on their website as:

> **"The Interactive, Programmable, Alternative Augmentative Communication (IPAAC) project is designed to provide a highly customizable form of alternative communication for children with disabilities. This is being done through a suite of communication programs for the iPad. The programs not only help children to communicate but also help them to develop language skills and other skills that are critical to communicating with others."**
> ***("EPICS_GLASS - Assistive Technology" 2012)***

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In the IPAAC team, engineering students led by Dr. Carla Zoltowski develop iPad applications for students with ASD based on research and support from community partners. The community partners included Dr. Oliver Wendt (Assistant Professor, Speech and Language Department at Purdue University) and the West Lafayette High School special education teachers. The idea and plan for these applications were developed from the community partners experience and knowledge of working with children with ASD. By participating in the development and deployment of some of these applications, I was motivated to start my thesis research in this route. As mentioned in the introduction, one of the objectives of this thesis work was to create an interaction design Definition Outline for Collaboration (DOC) to explore the potential and boundaries of developing iPad applications for autism therapy within the design community. My journey to achieve this objective started with my experience with the IPAAC (Interactive, Programmable, and Alternative Augmentative Communication) suite of applications.

This project was initiated as an assignment for the Intro to Interaction Design course in the fall semester of 2011. The main goals were to evaluate the current interaction of the applications, make suggestions for improvements, and support the development of the graphical user interface. There are five applications under development.

1. *Base:* This is a basic AAC device that uses the symbol based card system.

2. *Sentences:* This is a sentence creation application that uses the same symbol based card system as *Base*.
3. *Match:* The application has a predefined number of identical cards on the screen for the user to match.
4. *Sequential:* This is a step by step instructional guide that uses imagery as its basis for instruction.
5. *Coins:* This application allows the user to buy products.

All of these applications are customizable and designed for the unique needs of those with ASD. While participating in the IPAAC team, I had three main tasks to achieve. My first task was to observe children with autism using iPad applications to better understand the user experience. This project provided the opportunity to observe students with autism interact and use the iPad in the school environment and in the clinical environment. The next task during this project was to work with the team on evaluating and providing interaction support for the application called *Sentences.* The last task was to unify the look of all the applications with new names, icons, and graphic style sheets.

### 4.1 Observation: Learners with Autism Using the iPad

Observation was done at the West Lafayette High School (WLHS) special education classroom of the application *Sequential* and at the Purdue University Speech and Language Clinic of the application *Sentences.* During my observation at WLHS, I observed a group of students working at a large table doing a craft project. They were making a picture frame using a printed instruction worksheet with picture symbols for each of the steps. One student

was using the IPAAC application *Sequential* on the iPad that automates the paper instruction worksheets (Figure 4.1). It follows the same format as the sheet instruction, but provides for audio reinforcement and presentation of one signal at a time. Usability considerations that were identified during this observation were that the buttons needed to be large and that the requirements to accomplish tasks needed to be clear, simple and maintain one signal at a time.

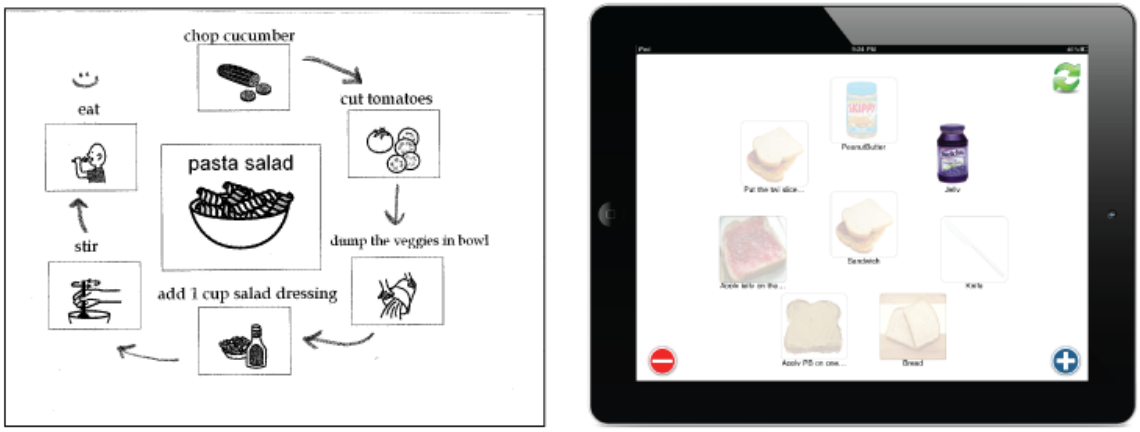


Figure 4.1 Example of instruction worksheet and *Sequential* IPAAC app

Observation of students using the application *Sentences* was conducted at the Speech and Language Clinic at Purdue University. They use an observation room with a live video feed of the instruction taking place by the clinician and student. The application *Sentences* is based on the PECS system of functional communication that uses symbol cards to communicate needs. *Sentences* automates this process on the iPad and adds audio reinforcement and customizable user settings. From these observations, I realized that customization would be an important usability consideration. Due to the varying

level of disability, the need to provide choices for usability is essential. Some students during the observation were able to use the drag and drop feature and some had difficulty with this action. Those who had difficulty tried to simply touch the card. This highlights the need for customization of user settings to accommodate the variable levels of ability. These experiences helped to inform my list of user requirements for application design.

## 4.2 Evaluation: Suite of Apps

As stated earlier, the applications were initially in a suite. The advantage of this metaphor is that they can share resources, but the disadvantage is that coding problems in one application could cause problems in the other apps and delay release of the apps that were ready. Eventually the applications were divided into individual projects because some had been built for deployment to the Apple App store while some were far from ready. Figure 4.2 shows the layout of the original suite of applications and the evaluation of the current usability flow for the application *Sentences* is wireframed.

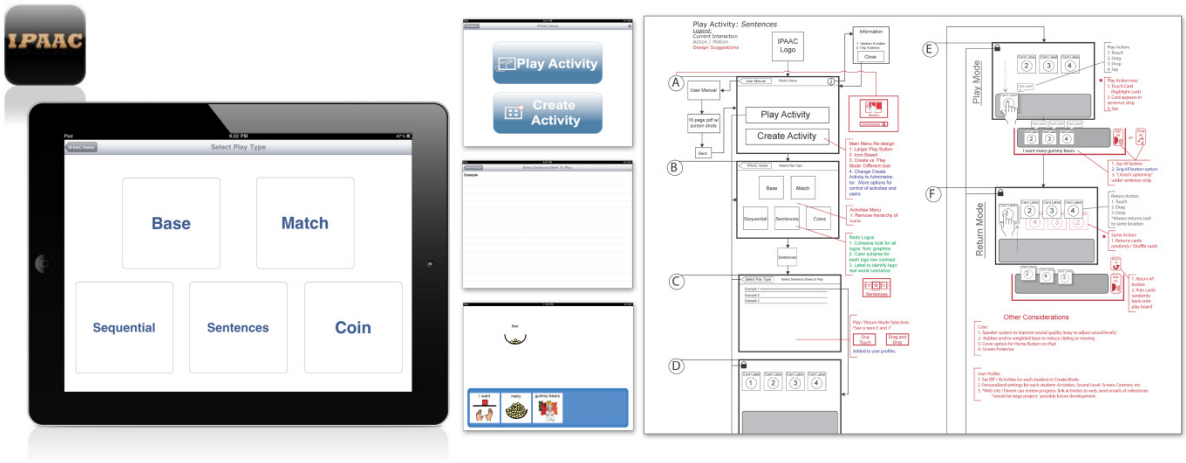


Figure 4.2 IPAAC suite of applications and evaluation of *Sentences*

## 4.3 Unify the Appearance and Application Names

Since the applications were in a suite, it is essential to unify the appearance and names that were fun, memorable, and descriptive of the application's function. I started with ideation sketches and lists of possible names (Figure 4.3). Then as a group we decided on the names: *Base* became *SPEAK one!, Sentences* became *SPEAK all!*, *Match* became *MATCH it!, Sequential* became *MAKE it!,* and *Coins* became *BUY it!* The apps would need to have a unified icon layout, color scheme, and a style sheet that could apply to the graphic instructions to apply to all of the applications. During the semester, the names, the icons, the color scheme, and the general style sheets were finished.

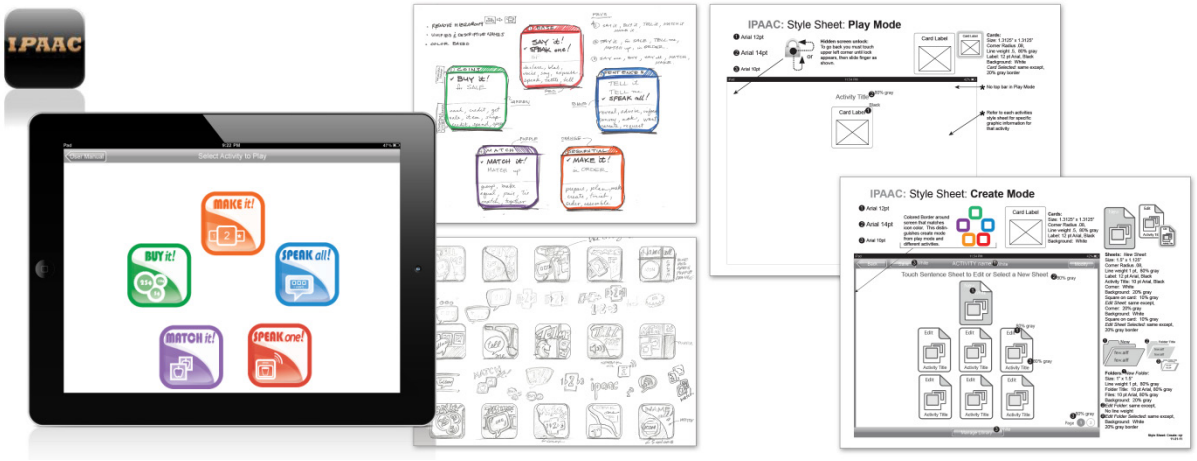


Figure 4.3 Unify look of suite of applications

## 4.4 Interaction Development and Suggestions for *SPEAK all!*

Apart from the unification, wireframing the suggested changes for the interaction design was completed. Considering the time limit of a one semester course, immediate improvements and suggestions for future development were outlined.

Those changes that were implemented during this semester for *SPEAK all!* included implementing the choice between “one-touch” and “drag and drop” play mode and adding a “speak all” button and a “return all” button on the play screen. Figure 4.4 and Figure 4.5 show the wireframes for play and create mode.

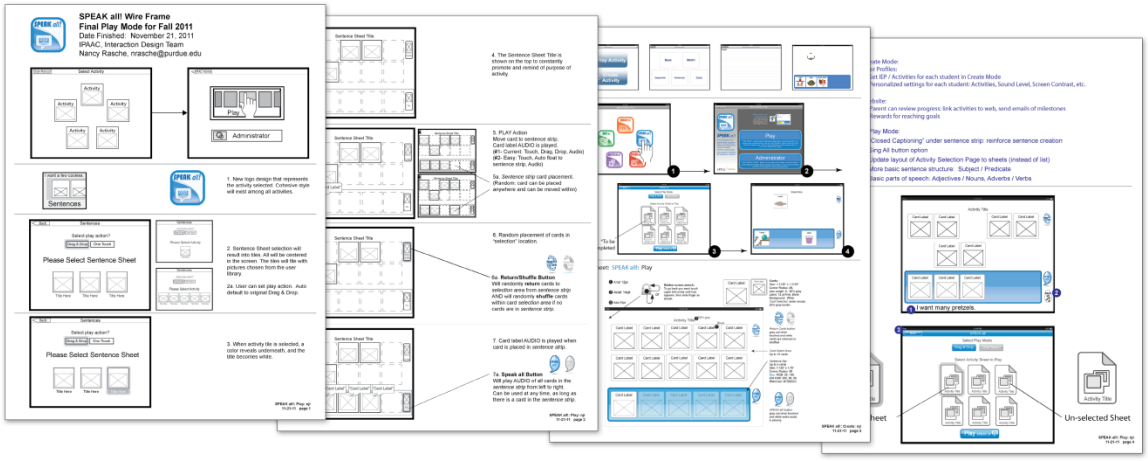


Figure 4.4 Wireframes for play mode of *SPEAK all!*

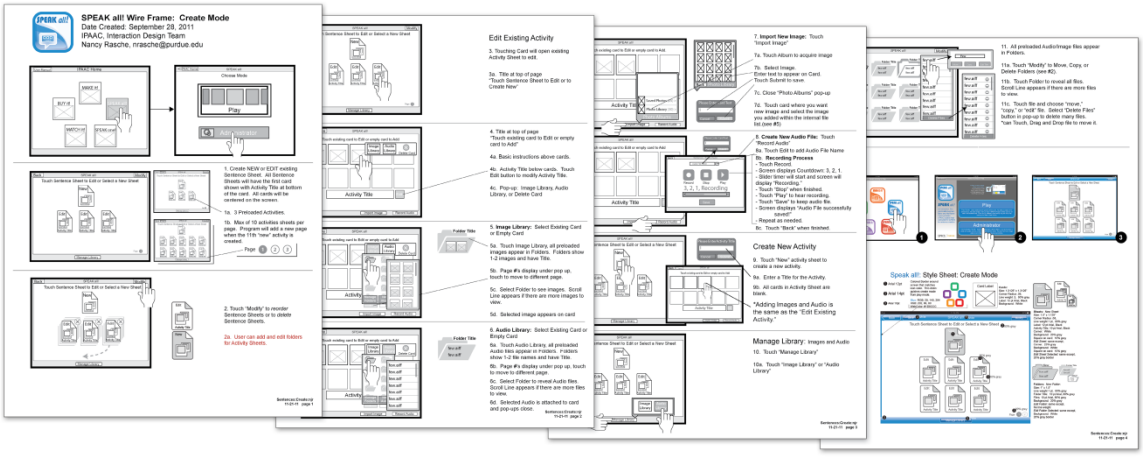


Figure 4.5 Wireframes for create mode for *SPEAK all!*

The last development in the project was the graphic design for the layouts, buttons, and screens for *SPEAK all!* Since this application was almost ready for release, it was necessary to remove it from the suite to prevent holding it back until the rest of the applications were ready. *SPEAK all!* was released to the iTunes store in November of 2011. The EPICS/IPAAC team continues to develop applications for children with ASD based on the user's needs that are identified by direct instructional techniques in the classroom or clinic.

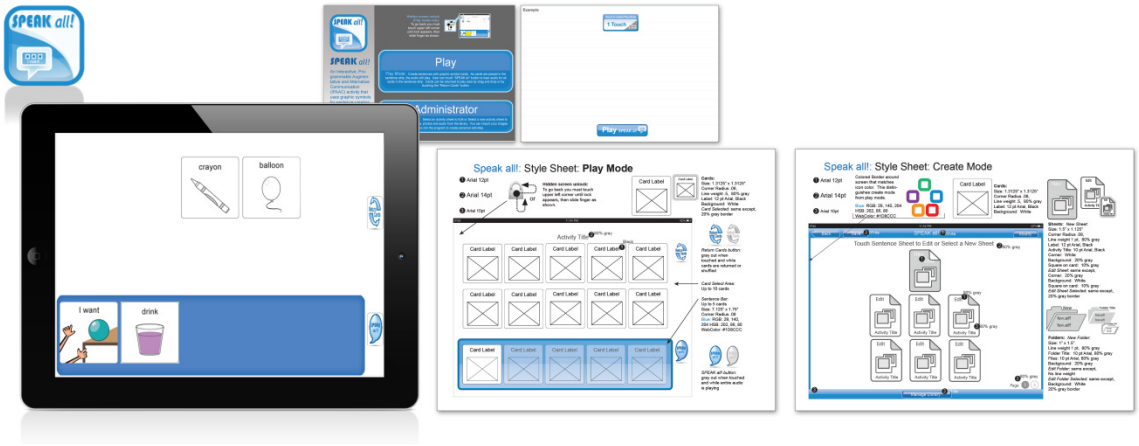


Figure 4.6 *SPEAK all!* released in fall 2011

## 4.5 Research Assistant Work - EPICS/IPAAC and *SPEAK all!*

Upon finishing this semester project with EPICS/IPAAC team, I was hired as a graduate assistant to participate in further development of the suite of applications and the professional development of *SPEAK all!* This assistantship continued through the last three semesters of my graduate degree. I had two roles in this assistantship. The first role was to support the EPICS/IPAAC engineering students with the development of all five applications. The second

role was to support the interaction and graphic development of *SPEAK all!* and other AAC iPad applications with Dr. Oliver Wendt. I was able to use the knowledge learned during this work and apply it to the development of my new application design for children with autism, *Literacy Labels.*

# CHAPTER 5. NEW STUDIES: DEVELOPMENT OF *LITERACY LABELS*

My previous work of conducting literary research reviews, synthesizing the information, and completing the foundation work paved the way to provide credibility to the design and development of the application *Literacy Labels*. The next chapter will detail the four-step design strategy cycle for this application. I explain my design strategy cycle stages as *define*, *design*, *develop*, and *deploy*. The first section of *define* will create the user profile and goals. This section is also what I used to create the DOC for the design community to develop applications for those with ASD based on information from the research community (CHAPTER 6).The DOC shows two possible paths to corroborate application design for the learner with autism. One path is to identify the application needs based on research methodology similar to the application development for *Literacy Labels* (6.2). The second path is to establish the application need based on direct instruction success like the application development of *SPEAK all!* (6.1). Automating a proven direct instruction skill or implementing a research-based methodology in a novel way is the first step toward establishing the path for application design. Both paths are detailed in the DOC to explain an idea for application development to facilitate the first step in the collaboration between the educator and the designer. *Speak all!* is shown

as an example of the direct instruction approach to the path of application development in the DOC only. While, the research based development of the application *Literacy Labels* will be documented in the complete design cycle strategy that will also include, *design*, *develop* and *deploy*.

## 5.1 DEFINE Phase

The first phase of the design cycle strategy began with the literature review and the direct observation of the user with the IPAAC project. This research created a foundation of the user persona and the goals for the application based on their needs. Thus, the application path is based on all the valuable user information and pedagogy for the skill to be designed in the application. The *define* phase starts with the design intent statement: *Literacy Labels* is designed to teach vocabulary using labeling to improve comprehension in children with ASD.

While considering the need to bring the design community and the research community together, it should happen here in the *define* phase. As stated in the beginning of the chapter, the DOC for an application is established in this phase. In order to explain the *define* phase, I introduce the DOC for *Literacy Labels* in this section which includes defining the five questions and providing the answers for them. The question are what, how, why, where, and who? Then in CHAPTER 6, the DOC questions are answered for the direct instruction application, *SPEAK all!* In the *define* phase of the design strategy cycle, the steps are to answer the DOC questions, visualize the user persona, and start the design document that will detail design intent and use cases.

### 5.1.1 Definition Outline for Collaboration (DOC) Questions

**Who?** *Creating the User Persona*

*Who are the users: background, abilities, needs and goals?* The user persona is a conceptual model of a representative person (Saffer 2010). It is based on a common set of behaviors and needs. The user profile creates a basic universal example of the user.

The user profile was created based on the research done in relationship to literacy development and learning process (Figure 5.1). Ideally this application should be customizable to fit the different skill levels of the users, but it should start with a focused set of levels and abilities based on the child with ASD. The application's design is for users who are learning to communicate or have learned to communicate and are showing the beginning signs of being ready to bridge toward reading.

**Why?** *Identifying necessity*

*Why is this pedagogy used and is this application design necessary?* This question deals with practicality. As was discussed earlier, some skills may not translate well to a mobile application. This section will deal with understanding the pedagogy of the skill and deciding whether or not it will benefit from automation in a mobile application. It is also important here to research the market for any similar application designs that are already available.

*Literacy Labels* automates the labeling process and adds audio and visual support to the learning. These are important features to emphasize for children with ASD. There are no applications focused on using the emergent literacy skill of vocabulary labeling for children with autism, particularly word/object association, to improve comprehension.

**How?** *Method of Implementation*

*How will this skill be currently implemented? How can it be implemented in a mobile application?* Explaining the pedagogy for the skill is required to make a detailed list of the purpose of the application. Detailing how the skill is currently taught as a direct instruction approach will help make the translation to the mobile application goals clearer.

Labeling objects is an emergent literacy skill that focuses on the association of the object and its orthography. It is currently implemented with written or printed labels placed on physical objects. The facilitator will use direct instruction to point out the label, spell the word and emphasis the association of the orthography to the object. Implementing this skill in a mobile application will require a readily known environment and objects: the home. It will need to support the unique learning style of the user group: visual emphasis, auditory reinforcement, repetition and a reward system.

**What?** *Application purpose*

*What are the goals?* As the earlier questions deal with setting up the primary need, this question deals with the completion goal. The creation of a detailed list of goals for the application based on the pedagogy and a statement of the application's completion goal will be required.

The purpose of *Literacy Labels* is to help children with autism prepare to read for meaning by using labeling. This application should be a first step in the process of emergent literacy skills before phonics and decoding skills are taught. By focusing on vocabulary teaching of actual objects in context, the goal is to improve the association between the orthography and the object. The completion goal for this application is for the user to learn the meaning of the orthography without the aid of the visual symbol or actual object.

**Where?** *TSMC and Application use*

*Where will the TSMC be used?* This question requires the definition of the environment and usability of the application.

The use of the iPad application will be predominately in the home or classroom learning environment. Depending on the user's abilities, a facilitator may be necessary to outline usability. The goal is to provide an easy way to understand the application that can hopefully be used independently after basic instruction.

The DOC for *Literacy Labels* is shown in Chapter 6 (6.2). These questions detail the pedagogy of the skill and how the application will achieve the goals of the user. All of this information can be summarized in a visual of the user persona (Figure 5.1).

### 5.1.2 User Persona

I gathered information during the *define* phase and applied them to create a visual of the user persona. This is an example of a representative user includes basic background, abilities, and objectives. The application was designed with the intent to improve comprehension in children with ASD. Nevertheless, this application can be an inclusive design that fits the widest possible audience - children with various types of learning disabilities and typical development preschoolers. An illustration of the user persona for the representative user, “Henry,” and the extended market is shown in Figure 5.1.


Figure 5.1 User persona of typical learner with autism and the expanded market for *Literacy Labels.*

### 5.1.3 Design Document

The design document is started in the *define* phase and is updated and modified throughout the development with the intent of being used in the deploy phase to explain the application design intent and strategy to the software developers. The design document in this phase should include all the *define* phase information.

The *define* phase detailed the design intent, the user persona, and the methodology of instruction. The *design* phase can now begin based on the comprehensive knowledge and understanding of the goals of the user. Combining this knowledge with the information learned about the strengths of the TSMC and software design for children with ASD will create the groundwork for ideation.

## 5.2 DESIGN Phase

The second phase began with a detailed understanding of the user and their goals. The *design* phase will include ideation sketching and wireframing ideas to design the basic application flow. The final deliverable of this phase is to construct a clear picture of the instructional method scenarios based on the goals for the application.

### 5.2.1 Ideation Sketches

The first step in the *design* phase is to sketch concepts to visualize possible ideas based on the user needs. Since the *define* phase identified a need to help in the area of comprehension, the first sketches show ways to achieve it. As some of the ideas were farfetched, the idea of teaching vocabulary in the home setting seemed promising. As the home setting provides a large amount of objects that the child should know and will support the concept of learning the vocabulary in context. During the first few rounds of sketching, the idea to use the iPad camera to scan QR codes on the labels emerged. The labels provide audio support to the instruction which is important to reinforce with the learner with autism who struggles in the area of verbal communication. Sketching

continued while developing the interaction design and graphical user interface for the game that will support the learning of the physical labels. The duality of the instructional methods was important since the learner benefits from repeated and varied instruction of skills. Below are some of the sketches that include early ideas and application design.

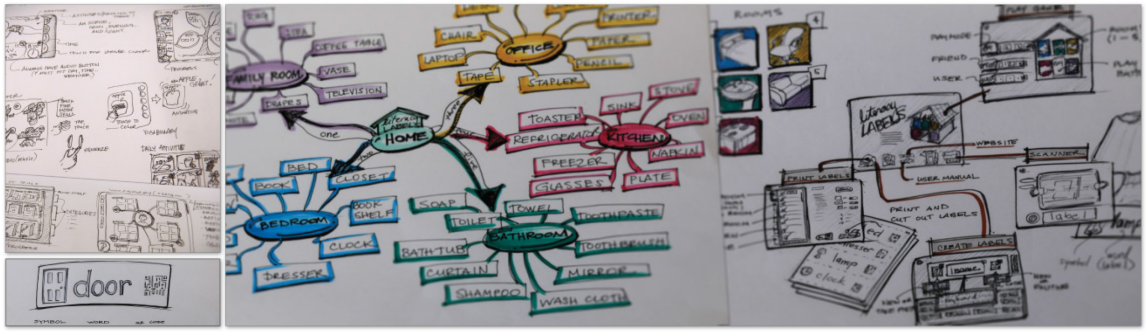


Figure 5.2 Ideation sketches, mind mapping, and app design

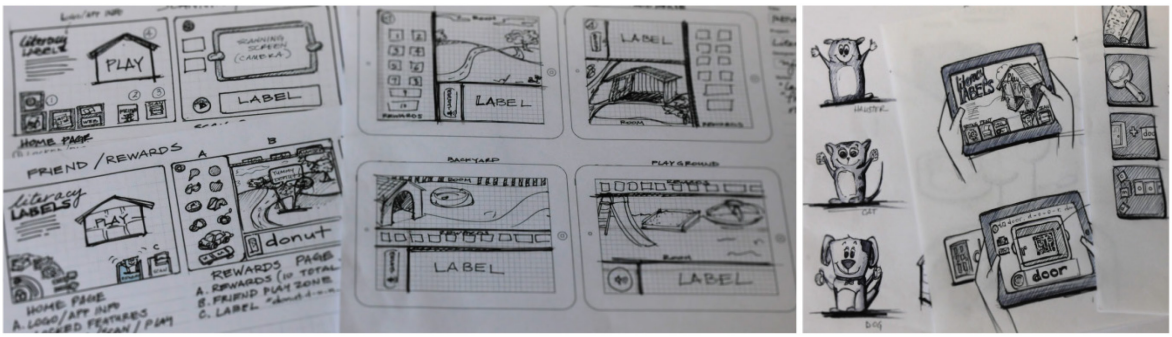


Figure 5.3 Further sketching into wireframes, layouts and graphics

### 5.2.2 Scenario

Based on the ideation sketches and development, I created the scenarios for the user as the two instructional methods.

- Label Scan Mode:  Using the iPad camera as a scanner, allows visual and audio responses for the printed labels.
- Game Play Mode:  Playing the game reinforces the skills being taught with the direct instruction of the labels.  Using these two methods can strengthen the association between the actual object and its corresponding orthography to improve comprehension.

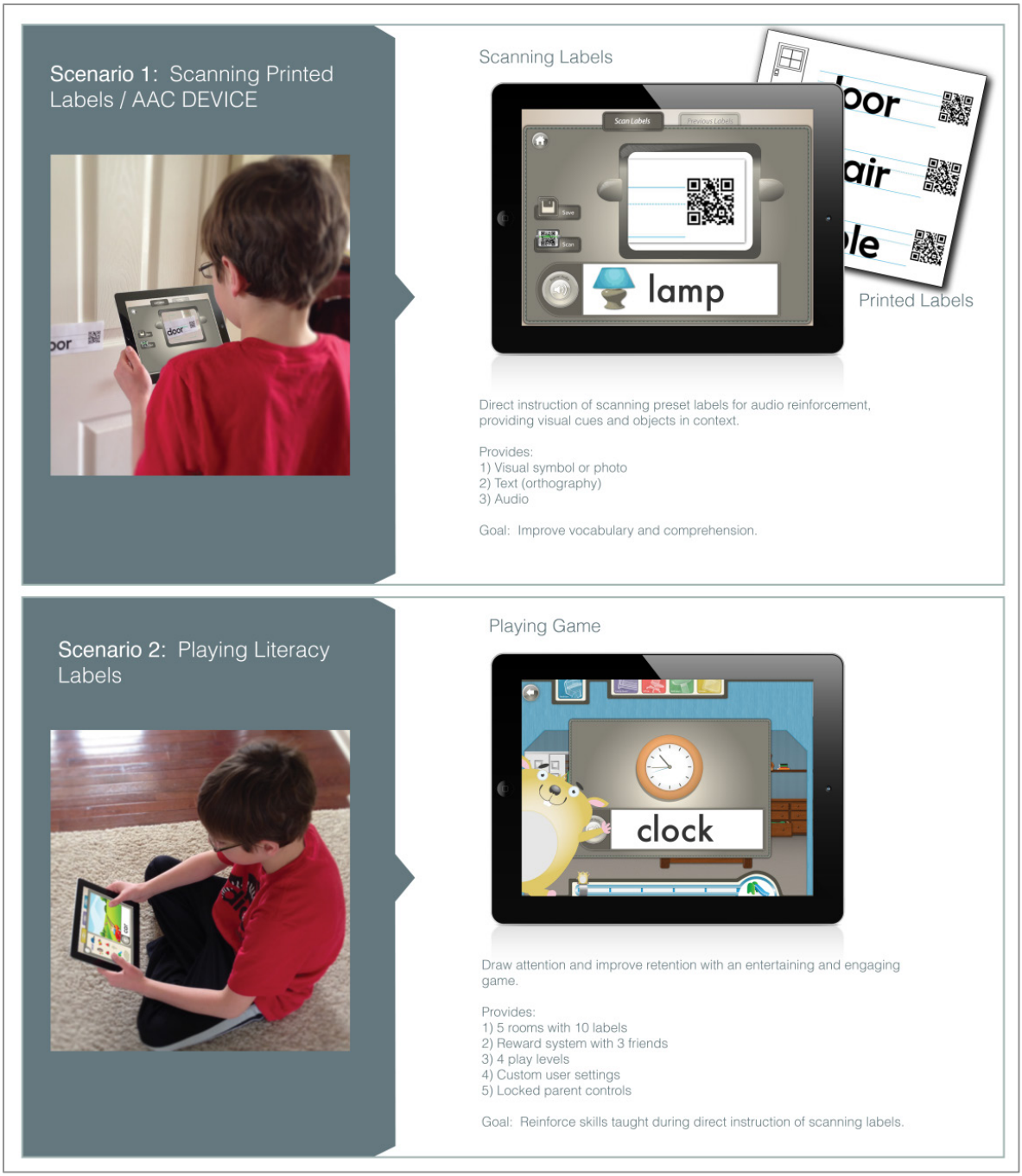


Figure 5.4 Scenarios of game play for the user

## 5.3 DEVELOP Phase

The third phase can begin when a clear understanding of the basic wireframe flow and the instructional methods for the application. The *develop* phase concentrated on the creation of an interactive system prototype for evaluation. In order to make this, a basic graphical layout was established, a final task flow, and a clear understanding of all the use cases. The use cases and task flow are detailed in the design document (Appendix A. ).

### 5.3.1 Mock-up and Formative Evaluation

I created an interactive system mock-up with Axure RP™ to conduct formative evaluations using a questionnaire with a focus group. A series of these evaluations were done at Purdue University's Speech and Language Clinic with professors, speech pathologists, and students. After analyzing the evaluation results (7.1), I made changes to the application's interaction and page layout. These changes were important the application's structural design. The design document was updated and modified to follow these changes to the design.

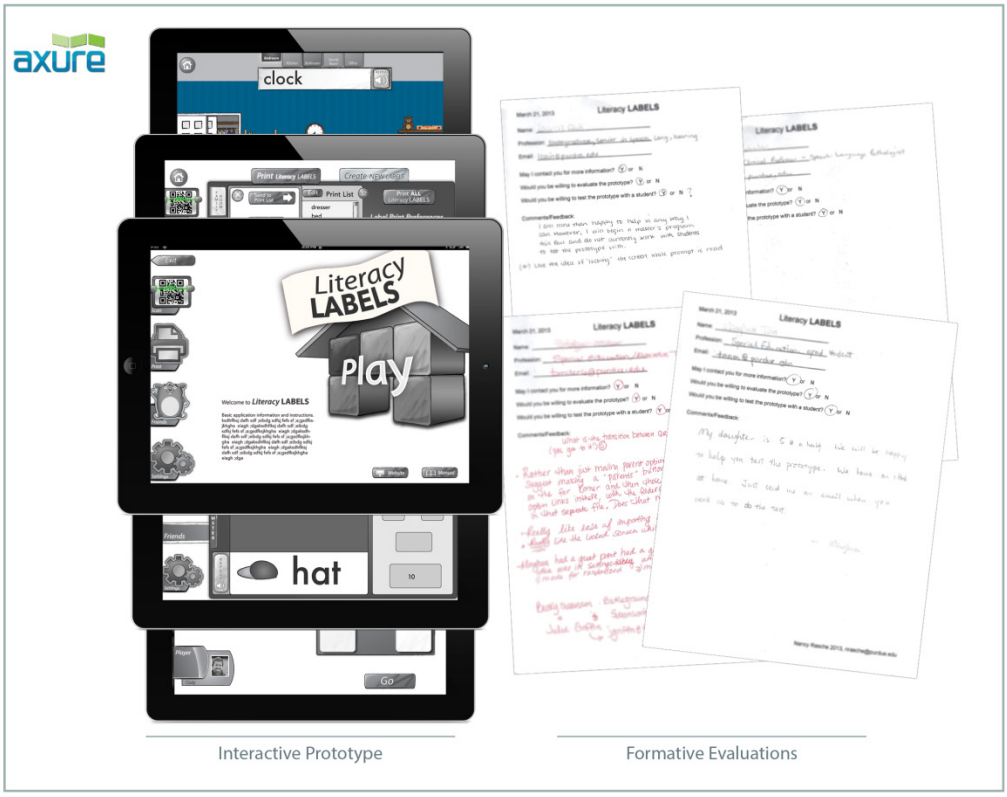


Figure 5.5 Interactive mock-up and sample of evaluations

### 5.3.2 Preliminary Graphics

The graphic design development continued during the prototyping phase. Considering the research on the learner with autism, it was important to avoid any unnecessary graphics to distract the user's attention. The final intended deliverable of the *develop* phase is to implement the feedback from this formative evaluation to the final design of the application before the deployment phase.


Figure 5.6 Preliminary graphical user interface development

## 5.4 DEPLOY Phase

The *deploy* phase of the design strategy cycle begins with the intent of preparing a prototype for final evaluation and concluding the design document for the software developers. This will include the completing of the graphics and the application flow with a final explanation of use and features. Ideally the application prototype would be professionally coded for summative evaluation. This was not possible with the timing of this thesis conclusion. As discussed in the next section, the future goals will be explained. Basically, as more time and funding allows, the application can be tested further with the users.

### 5.4.1 Interactive Prototype

An interactive prototype was created in GameSalad to receive more feedback from educators about the design's development and validity. A prototype of the

scanning of labels and one room of the seek and find play mode was created with Flash action script. Due to the limitations of using this with the iPad and difficulties with time and funding, the prototype was not mature enough to test with real users.

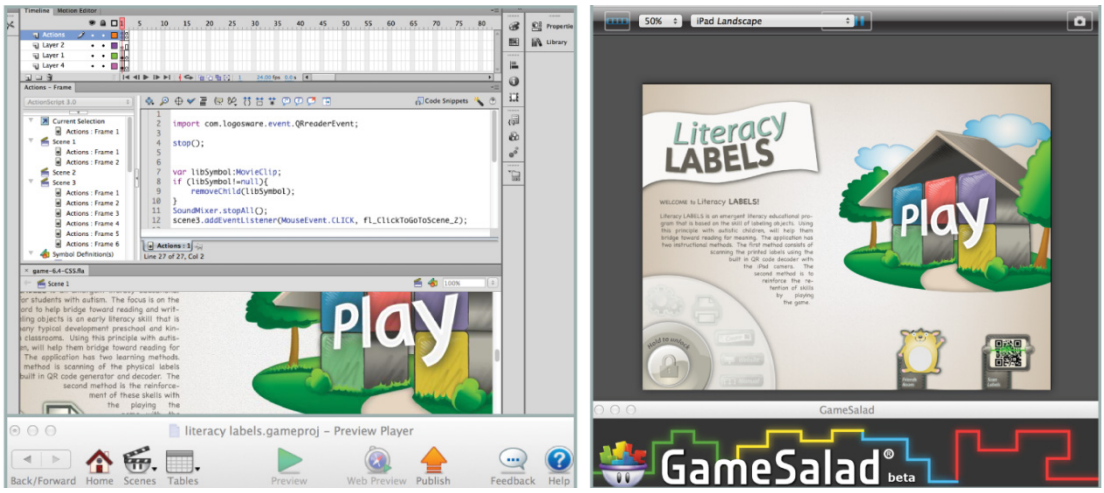


Figure 5.7 Prototypes in Flash and GameSalad

### 5.4.2 Final Design Document

The design document was finalized and prepared for completion of the design process. The design document includes the design history, game overview, common questions, feature set, four play modes, environment, reward system, and the game set up. The entire design document for *Literacy Labels* is included in Appendix A. Design Document.


Figure 5.8 Sample of design document

# CHAPTER 6. DEFINITION OUTLINE FOR COLLABORATION (DOC)

In CHAPTER 5, the questions for a DOC were listed and answered for the new application *Literacy Labels*. It can also be done for a direct instructional technique application, such as *SPEAK all!* The answers to the *define* questions will help the designer understand the user and their goals. In this chapter, an illustration of both paths of the DOC will be shown: research based approach (*Literacy Labels*) and direct instructional technique (*SPEAK all!*). This DOC is meant to be a simple way to facilitate the beginning of collaboration between the researchers and the designers with the common objective of helping those with ASD with applications that support their instructional needs. There is also a blank user persona page that can be filled out. This can supplement the DOC and provide more information for the designers. The development of the entire application, of course, will require much more than this DOC. The next three stages of *design*, *develop*, and *deploy* will need to follow based on the framework of the DOC. Once the *define* phase has been completed, it is time to pitch it to the design community. Basically, no application design can start without definition and no design idea will get developed without a catalyst for collaboration. Hopefully this is enough to get the ball rolling.

For illustration, I answered the questions in these DOC examples from the knowledge learned during the development of *Literacy Labels* and during my involvement with the EPICS team development of *SPEAK all!* There is a blank DOC in the appendix for design ideas to be explored. Thus, these two types of approaches to application design development for the DOC that can be used to begin the collaboration between the educator and designer to enhance the quantity and effectiveness of applications for those with ASD.

### 6.1 DOC Example for Direct Instruction

## Definition Outline for Collaboration (DOC)

**Application Name:** SPEAK all!
**Design Intent:** *SPEAKall!* is an alternative augmentative communications solution for the iPad. It uses symbol based communication.

**Who?** *Creating the User Persona*

*Who are the users: background, abilities, needs and goals?* Create a basic universal example of the user.

Speak all! is for learners with less than 5 communicable words. The disabilities are varied and the age is based on when needed. The user is someone with little to no communicable speech who is cognitively capable of acquiring speech.

**Why?** *Identifying necessity*

*Why is this pedagogy used and is this application design necessary?* List benefits of automation and define research into similar applications.

The research has shown that the direct instruction of symbol based cards can help children with ASD establish functional communication.

Direct one on one instruction requires time and set up. Sometimes the communication is necessary and the cards are not available. This skill can benefit from customization and automation.

| **How?** *Method of Implementation* |
| --- |
| *How is this skill currently implemented?* Explain pedagogy for the skill.<br><br>*How can it be implemented in a mobile application?* Detail use for mobile application. |
| Direct Instruction: Direct one on one instruction in context. The symbol cards represent the word or need and are handed to the facilitator to indicate functional communication.<br><br>Application: Will follow the same direct instruction format with child and facilitator, but will include audio with the cards like an AAC device. |

| **What?** *Application purpose* |
| --- |
| *What are the goals?* Purpose and completion goal for the application. |
| Use symbol based cards to establish functional communication for those who are nonverbal.<br>Requirements: It must support the establishment of functional communication. It must provide symbols, audio and customization. It should also allow for sentence formation and learning of more symbols.<br><br>The main completion goal is to support the establishment of functional communication. The secondary goals are to establish verbal communication and learn extended skills. |

| **Where?** *TSMC and Application use* |
| --- |
| *Where will the TSMC be used?* Define the environment and use of the application. |
| The application will be used in the clinical environment until basic use is established. It can then be implemented in the home or any other environment the child would need to use it to communicate. |

Figure 6.1 DOC example for *SPEAK all!*, direct instruction

## 6.2 DOC Example for Research Approach

# Definition Outline for Collaboration (DOC)

**Application Name:** *Literacy Labels*
**Design Intent:** *Literacy Labels* is designed to teach vocabulary using labeling to improve comprehension in children with ASD.

### **Who?** *Creating the User Persona*

*Who are the users: background, abilities, needs and goals?* Create a basic universal example of the user.

*Literacy Labels* is for children with ASD who are developing communication and are ready to bridge toward learning emergent literacy skills. The application should have customizable user profiles to allow for different levels of ability.

### **Why?** *Identifying necessity*

*Why is this pedagogy used and is this application design necessary?* List benefits of automation in mobile application and define research into similar applications.

NEED: There is a common thread of lack of comprehension skills in children with ASDs.

*Literacy Labels* automates the labeling process and adds audio and visual support. There are currently no applications focused on using the emergent literacy skill of vocabulary labeling for children with autism, particularly word/object association, to improve comprehension.

### **How?** *Method of Implementation*

*How is this skill currently implemented?* Explain pedagogy for the skill.
*How can it be implemented in a mobile application?* Detail use for mobile application.

Direct instruction: Create labels and place on objects. Labels are pointed to, spelled or interacted with to indicate the orthography of the object.

Application SCAN LABELS mode: will allow for direct instruction but can extend to individual scanning of the labels as it will provide audio feedback like an AAC device and visual feedback on the screen with the label and animation.
Application: PLAY GAME mode: the game will be used to reinforce skills and can be used independently.

**What?** *Application purpose*

*What are the goals?* Purpose and completion goal for the application.

Use orthography based labels to teach vocabulary that will associate meaning between the object and the written word, versus basic word recognition.
Requirements: SCAN LABELS MODE: 1). It must connect the orthography with the object. 2). It must provide labels to print, means for scanning labels without Wi-Fi, provide audio support, and be customizable.
PLAY GAME MODE: 1). Must reinforce the skills being taught with the physical labels. 2). It must be education focused, provide a rewards system, provide audio support and have the same label format as the physical labels.

The completion goal for this application is for the user to be able to understand the meaning of the orthography without the aid of the visual symbol or actual object.

**Where?** *TSMC and Application use*

*Where will the TSMC be used?* Define the environment and use of the application.

The SCAN LABELS MODE would start in the home environment because that is where the labels are matched to the objects. It can then extend to other environments with the creation of custom labels or uploaded content.
The PLAY GAME MODE can be played anywhere because all of the content is embedded in the application.

Depending on the user's abilities, a facilitator may be necessary to outline usability. The goal is to provide an easy way to understand the application that can be used independently after basic instruction.

Figure 6.2 DOC example for *Literacy Labels*, research method

# CHAPTER 7. PRELIMINARY EVALUATION

Throughout the design process, I gathered qualitative research through conducting several kinds of preliminary evaluations. This information provided insight and inspiration to the design and strategy of the application. These evaluations were done with autism educators, clinicians, and students. The first formative evaluation was done with a focus group in March of 2013 with faculty and students at Purdue's Speech and Hearing department. The second evaluation of the methodologies for *Literacy Labels* was done in May 2013 by interviewing two researchers who are specialists in early literacy and ASD.

## 7.1 Focus Group Evaluation

In March of 2013, I used an interactive system mock-up of the application to conduct a focus group evaluation of the application's interaction design and methodologies with 10 faculty, clinicians and grad students in Purdue's Speech and Hearing Sciences School. This evaluation was set up as an exploratory review. The evaluators were set up as a focus group with a written questionnaire to fill out during the presentation of the prototype. Additional comments and responses were communicated verbally at the end of the presentation and questionnaires were collected. I compiled the information into categories of structured findings. The three main areas are methodology, function, and

customization. In the table below, I summarize some of the information findings along with action items that were implemented in the application after the evaluation. It was also important to maintain an open conversation with these evaluators for future feedback and evaluations, so contact information was requested.

| Literacy Labels: Formative Evaluation |
|---|
| **System:** Presentation of interactive prototype made with Axure RP<br>**Evaluator Name:** Professors-2, Graduate Students-6, and Undergrads-2<br>**Profession:** Special Education Teachers, Speech Therapists, and Students<br>**Date:** March 21, 2013 |
| Key: ■ : Comments ■ : Action items |

| METHODOLOGY | |
|---|---|
| Direction | *"Great idea, could have dual benefit with using as an AAC device."*<br><br>*"Will help expand vocabulary."* |
| User needs: repetition | *"Many will need a lot of repetition of the same skills."* |
| User needs: feedback | *"Need to have immediate and frequent feedback. Make sure it is only for correct responses. There should be no reward for incorrect"* |
| User needs: feedback | *"Provide levels of instruction. First wrong, second wrong, move to next…"* |

| FUNCTION | |
|---|---|
| Parent Controls | *"Put the parent control in one button, or locked."* |
| Screen lock during reading of prompt | *"Love the idea of 'locking' the screen while the prompt is being read."* |

| CUSTOMIZATION | |
|---|---|
| Setting options in each play mode | *"Allow for less items in a room and a mode for randomization."*<br>*"Make it so you can repeat it a set number of times"* |
| Custom labels | *"Really like the ease of importing images and saving labels."* |

| FUTURE | |
|---|---|
| Future help: test prototype with student? | *Yes - 5* |
| Future help: evaluate prototype? | *Yes- 8* |

Table 1 Summary of focus group questionnaire

Based on their experience, the evaluators confirmed the methodology of teaching vocabulary with labeling as a credible path to help children with ASD improve

comprehension skills. They were also able to give me constructive feedback on how to improve the application usability based on their experience.

- Allow customization based on skill level within each of the play modes was suggested and implemented in the application.
- Place all of the parent/facilitator controls in a locked area. The change for this feedback is shown in Figure 7.1.
- Provide step by step instruction for teaching during incorrect responses was added (Appendix A. ).

This evaluation was an important step in the development of this application. It was necessary to have feedback from those who have expansive knowledge of working with children with autism.


Figure 7.1 Example of changed parent controls

## 7.2 Interview of Early Literacy Specialists

In May of 2013, I interviewed two specialists in early literacy and ASD at Purdue University, Dr. Anu Subramanian and Dr. Christi Masters; both are speech and language pathologists with early literacy intervention experience. During these interviews, my two objectives were to verify the need for a literacy based intervention application such as *Literacy Labels* and to get feedback on the current application design. I learned that there is a need for comprehension improvement beyond children with ASD. Dr. Masters mentioned that new studies indicate that children with speech delays are at a higher risk of developing literacy and comprehension difficulties. She also mentioned that the adoption of the common core curriculum in many states means that there could be another use for *Literacy Labels*. It could be used to teach the core vocabulary standards for those who would benefit from audio/visual support and repeated training. Both of these interviews were important steps in the development process. They helped to create a list of possible versions of the application that could be developed in the future.

# CHAPTER 8. CONCLUSION AND FUTURE WORK

In conclusion, the development of an application for children with autism was a challenging and rewarding experience. The in-depth research required to understand the unique user requirements was enlightening. To make decisions founded on the learner's needs, researching ASD impairments, learning style, literacy development, and TSMC for autism instruction was essential. Ideation was based on the synthesis of this research groundwork that was used to create the model of the zones of instruction, the information processing interruption model, the illustration of emergent literacy skills, the strengths of TSMC illustration, and the list of the software design considerations for children with autism. Literature reviews and real world observation together made the investigation into ASD more relevant. By observing the users interact with iPad application, I could see the significance of the examination and how it applies to children with ASD.

The future work and expansion for *Literacy Labels* is described as the design strategy cycle continues. My final objective is to have this application on the iTunes store for children to use. In order to achieve this, I detail the intent for evaluation of the scanning mode for *Literacy Labels* and a plan to evaluate the

methodology of the DOC. Expansion topics include further development of the graphical user interface, exploring the core curriculum initiative further, and researching possible alternate scanning options.

## 8.1 Future Evaluations for *Literacy Labels* and DOC

Evaluation of specific parts of the application can be done before the coding of the prototype is complete. This includes the scanning of the labels with a Wi-Fi based QR code scanner application, such as *QRvox*. Also, the validity of the Definition Outline for Collaboration can be measured with educators and designers to see if can provide a bridge for collaboration.

### Alternate Solutions for Evaluation the Scanning of the Labels

The physical label part of the application can be tentatively evaluated with printed labels and a free Wi-Fi based QR code scanner app, such as *QRvox*. This is not ideal because the Wi-Fi scanners add extra steps to the process that will make it more difficult to operate and will not link to an image. Ideally, I would like to have the application design working in order to get accurate results. But, often ideal is not possible. I plan to test the methodology of scanning the printed labels to see if vocabulary is learned and retained with a Wi-Fi scanner. Evaluating the validity of using labels for vocabulary instruction will create the basis for the summative evaluations of the software.

### Formative Evaluation of the DOC

During the development of this thesis, I was able to make good contacts with teachers and clinicians in the autism community. I plan to have the DOC tested by these individuals. Instructions are to fill out the DOC based on a direct

instruction technique and then have designers translate it into a design idea. Then the collaboration can begin. It can be reviewed by the teachers to see if what they intended was created and then continue developing the idea further. The design strategy cycle is an iterative process that is not linear. Often it is necessary to go back and change or modify. This evaluation of the Definition Outline for Collaboration could create an alliance between the educators and designers that could lead to more applications.

## 8.2 Translation and Expansion

The adoption of the common core curriculum means that there is a set list of goals to be achieved for each grade level. Similar to an Individual Education Plan (IEP) that is in place for children with special needs, these are set objectives that should be obtained by the end of the school year and will be evaluated on standardized testing. This curriculum could be supplemented on the iPad with *Literacy Labels* for vocabulary, spelling, word recognition, sight words, etc. This expansion possibility needs to be researched further to see if it has merit for *Literacy Labels*.

As for scanning the labels, one possible way around the problem with the open source QR codes not translating to the TSMC is to research other ways to scan the labels. I like the accessibility of QR codes because you can use any smart phone to scan the labels, but it is restrictive in that smart phones will require Wi-Fi. Whether or not the labels have QR codes is a question that needs to be explored. There are optical character recognition (OCR) applications that read

text. These could be used as they would read the text and link to the label/image/audio in the code. Such applications as *Pixter Scanner OCR* and *Text Grabber* will be evaluated as examples of OCR. Another option is the image to text scanners like *Image to Text HD*. These applications attach text to an image than it can be scanned to reveal the text. Again this type of scanning will have to be evaluated to see if it is feasible for implementation in the application.

Lastly, development of the graphical user interface is continuing. The basic graphics were created to show the flow of the application and visualize the intent. The final look of the application needs to be designed and all of the pages, buttons and features need to be finalized.

In summary, the design of *Literacy Labels* was based on literacy research pertaining to children with ASD having a common thread of difficulties with reading comprehension. The mission of this application is to improve this situation by teaching the emergent literacy skill of vocabulary instruction with labeling before independent reading begins. *Literacy Labels* has two instructional methods that include scanning QR codes on printed labels with the iPad camera and playing a fun game within the application to reinforce the skills. The goal of combining these two learning methods is to strengthen the understanding that all words have meaning before the child learns to read independently by using decoding skills.

My primary purpose was to design applications for children with special needs. This socially responsible design directive has fueled my work and desire to achieve my goal. As the intent spread to creating collaboration between the design community and the research community, I started to see an opportunity to serve this user group in a more comprehensive manner. The first step of one application design is small, but the bigger picture of enticing collaboration brings forth the opportunity to possibly make a difference. This journey has been one of exploration and appreciation of the children with ASD and those who work tirelessly to help them. They are truly inspiring.

NOTES

# NOTES

1. Pyramid Educational Consultants, Inc., Newark, DE, is a registered trademark.
2. ProxTalker is a registered trademark of ProxTalker.com, LLC, Waterbury, CT.
3. Picture Communication Symbols are a registered trademark of DynaVox Mayer-Johnson, Pittsburgh, PA.
4. *SPEAK all!* is a registered trademark of Speak Modalities.
5. Proloquo and Proloquo2go are registered trademarks of AssistiveWare, Laurierstraat 1831016PL Amsterdam.
6. QRvox is a registered trademark of JWay Group, Inc.
7. Pixter Scanner OCR is a registered trademark of Quanticapps.
8. Text Grabber is a registered trademark of ABBYY Software Ltd.
9. Image to Text HD is a registered trademark of Ricoh Innovations, 2882 Sand Hill Road, Suite 115, Menlo Park, CA 94025.
10. AxureRP is a registered trademark of Axure Software Solutions, 311 Fourth Avenue, Ste 617, San Diego, CA 92101
11. GameSalad is a registered trademark of GameSalad, Inc., 9600 Great Hills Trail, Austin, TX 78759
12. Flash is a registered trademark of Adobe Systems Incorporated, a Delaware corporation, 345 Park Avenue, San Jose, California 95110.

# BIBLIOGRAPHY

# BIBLIOGRAPHY

Autism Society. 2011. “Autism Society - Facts and Statistics.” http://www.autism-society.org/about-autism/facts-and-statistics.html.

Boesch, Miriam C., Oliver Wendt, Anu Subramanian, and Ning Hsu. 2013. “Comparative Efficacy of the Picture Exchange Communication System (PECS) versus a Speech-Generating Device: Effects on Social-Communicative Skills and Speech Development.” *Augmentative and Alternative Communication* 29 (3) (September): 197–209. doi:10.3109/07434618.2013.818059.

Carter, Alice S., Naomi Ornstein Davis, Ami Klin, and Fred R. Volkmar. 2005. “Social Development in Autism.” In *Handbook of Autism and Pervasive Developmental Disorders*, edited by Fred R. Volkmar, Rhea Paul, Ami Klin, and Donald Cohen, 312–334. John Wiley & Sons, Inc. http://onlinelibrary.wiley.com/doi/10.1002/9780470939345.ch11/summary.

CDC. 2012. “Centers for Disease Control and Prevention: Prevalence of Autism Spectrum Disorders — Autism and Developmental Disabilities Monitoring Network.” *Morbidity and Mortality Weekly Report* 61 (3): 1–19.

Clay, Marie M. 1966. “Emergent Reading Behaviour”. Thesis, ResearchSpace@Auckland. https://researchspace.auckland.ac.nz/handle/2292/778.

“EPICS_GLASS - Assistive Technology.” 2012. *Greater Lafayette Area Special Services*. Accessed April 16. http://epics.ecn.purdue.edu/glass-at/.

Fletcher-Watson, S., and H. McConachie. 2010. “Interventions Based on the Theory of Mind Cognitive Model for Autism Spectrum Disorder (ASD).” *The Cochrane Library*.

Flores, Margaret, Kate Musgrove, Scott Renner, Vanessa Hinton, Shaunita Strozier, Susan Franklin, and Doris Hil. 2012. “A Comparison of Communication Using the Apple iPad and a Picture-Based System.” *Augmentative and Alternative Communication* 28 (2) (June): 74–84. doi:10.3109/07434618.2011.644579.

Frost, Lori A., and Andrew S. Bondy. 2002. *The Picture Exchange Communication System Training Manual*. Pyramid Educational Products, Incorporated.

Grigorenko, Elena L, Ami Klin, David L Pauls, Riley Senft, Catalina Hooper, and Fred Volkmar. 2002. “A Descriptive Study of Hyperlexia in a Clinically Referred Sample of Children with Developmental Delays.” *Journal of Autism and Developmental Disorders* 32 (1) (February): 3–12.

Grigorenko, Elena L., Ami Klin, and Fred Volkmar. 2003. “Annotation: Hyperlexia: Disability or Superability?” *Journal of Child Psychology and Psychiatry* 44 (8): 1079–1091. doi:10.1111/1469-7610.00193.

Happé, F. 1999. “Autism: Cognitive Deficit or Cognitive Style?” *Trends in Cognitive Sciences* 3 (6): 216–222.

Hollands, J. G, and C. D Wickens. 1999. *Engineering Psychology and Human Performance.* Prentice Hall New Jersey.

Hurewitz, Felicia, and Katharine Beals. 2008. “A Role for Grammar in Autism CAIs.” In *Proceedings of the 7th International Conference on Interaction Design and Children*, 73–76. IDC ’08. New York, NY, USA: ACM. doi:10.1145/1463689.1463722. http://doi.acm.org/10.1145/1463689.1463722.

“iConverse.” 2013. *iConverse*. http://www.converseapp.com/.

“IPAAC EPICS.” 2013. *SPEAK All!* Accessed November 24. http://epics.ecn.purdue.edu/ipaac/.

Izzo, Margaretha Vreeburg, and William M. Bauer. 2013. “Universal Design for Learning: Enhancing Achievement and Employment of STEM Students with Disabilities.” *Universal Access in the Information Society*: 1–11. doi:10.1007/s10209-013-0332-1.

Johnson, Michelle. 2013. “The Effectiveness of iPads in Special Education Focusing on Autistic Children.” http://www.pipermints.com/ci5630/webpage/iPads%20in%20Special%20Ed%20Focusing%20on%20Autistic%20Children.pdf.

Justice, Laura M., and Khara L. Pence. 2004. “Addressing the Language and Literacy Needs of Vulnerable Children Innovative Strategies in the Context of Evidence-Based Practice.” *Communication Disorders Quarterly* 25 (4) (September 1): 173–178. doi:10.1177/15257401040250040201.

Kathleen Ann Quill, and Temple Grandin. 1995. *Teaching Children with Autism: Strategies to Enhance Communication and Socialization: Chapter 2*. Cengage Learning.

Lanter, Elizabeth, Linda R. Watson, Karen A. Erickson, and Daniel Freeman. 2012. “Emergent Literacy in Children With Autism: An Exploration of Developmental and Contextual Dynamic Processes.” *Language, Speech, and Hearing Services in Schools* 43 (3) (July 1): 308–324. doi:10.1044/0161-1461(2012/10-0083).

Lernihan, Katy. 2012. “Teaching with Technology.” http://www.longwood.edu/admissions/42176.htm.

Light, Janice C, Barbara Roberts, Rosemarie Dimarco, and Nina Greiner. 1998. “Augmentative and Alternative Communication to Support Receptive and Expressive Communication for People with Autism.” *Journal of Communication Disorders* 31 (2) (March): 153–180. doi:10.1016/S0021-9924(97)00087-7.

Liss, Miriam, Celine Saulnier, Deborah Fein, and Marcel Kinsbourne. 2006. “Sensory and Attention Abnormalities in Autistic Spectrum Disorders.” *Autism* 10 (2) (March 1): 155–172. doi:10.1177/1362361306062021.

“Longwood Alumna Uses Ipads to Help Students with Autism.” 2012. *US Fed News Service, Including US State News*, March 22. http://search.proquest.com/docview/929702529/fulltext?source=fedsrch&accountid=13360.

Morris, Robert R., Connor R. Kirschbaum, and Rosalind W. Picard. 2010. “Broadening Accessibility through Special Interests: A New Approach for Software Customization.” In *Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility*, 171–178. ASSETS ’10. New York, NY, USA: ACM. doi:10.1145/1878803.1878834. http://doi.acm.org/10.1145/1878803.1878834.

Murray, Orrin T., and Nicole R. Olcese. 2011. “Teaching and Learning with iPads, Ready or Not?” *TechTrends* 55 (6) (November 1): 42–48. doi:10.1007/s11528-011-0540-6.

Myles, Brenda S., Richard L. Simpson, Christine K. Ormsbee, and Courtney Erickson. 1993. “Integrating Preschool Children with Autism with Their Normally Developing Peers: Research Findings and Best Practices Recommendations.” *Focus on Autistic Behavior* 8 (5): 1–18.

Nation, Kate, Paula Clarke, Barry Wright, and Christine Williams. 2006. “Patterns of Reading Ability in Children with Autism Spectrum Disorder.” *Journal of Autism and Developmental Disorders* 36 (7) (October 1): 911–919. doi:10.1007/s10803-006-0130-1.

Ozonoff, S., D. L Strayer, W. M McMahon, and F. Filloux. 1994. “Executive Function Abilities in Autism and Tourette Syndrome: An Information Processing Approach.” *Journal of Child Psychology and Psychiatry* 35 (6): 1015–1032.

Pellicano, E. 2010. “Individual Differences in Executive Function and Central Coherence Predict Developmental Changes in Theory of Mind in Autism.” *Developmental Psychology* 46 (2): 530.

“Proloquo2Go.” 2013. *AssistiveWare*. Accessed November 24. http://www.assistiveware.com/product/proloquo2go.

“ProxTalker.com.” 2013. January 8. http://www.proxtalker.com/proxtalker.

Putnam, C., and L. Chong. 2008. “Software and Technologies Designed for People with Autism: What Do Users Want?” In *Proceedings of the 10th International ACM SIGACCESS Conference on Computers and Accessibility*, 3–10.

“Pyramid Educational Consultants, Inc.” 2013. Accessed November 8. http://www.pecsproducts.com/catalog/product_info.php?products_id=45.

Quill, Kathleen A. 1997. “Instructional Considerations for Young Children with Autism: The Rationale for Visually Cued Instruction.” *Journal of Autism and Developmental Disorders* 27 (6) (December 1): 697–714. doi:10.1023/A:1025806900162.

Ramdoss, Sathiyaprakash, Wendy Machalicek, Mandy Rispoli, Austin Mulloy, Russell Lang, and Mark O’Reilly. 2012. “Computer-Based Interventions to Improve Social and Emotional Skills in Individuals with Autism Spectrum Disorders: A Systematic Review.” *Developmental Neurorehabilitation* 15 (2) (April): 119–135. doi:10.3109/17518423.2011.651655.

Rasche, N., and C.Z. Qian. 2012. “Work in Progress: Application Design on Touch Screen Mobile Computers (TSMC) to Improve Autism Instruction.” In *Frontiers in Education Conference (FIE), 2012*, 1–2. doi:10.1109/FIE.2012.6462516.

Rice, Catherine. 2009. “Prevalence of Autism Spectrum Disorders -- Autism and Developmental Disabilities Monitoring Network, United States, 2006.” *MMWR Surveillance Summaries* 58 (SS-10) (December 18): 1–24.

Saffer, Dan. 2010. *Designing for Interaction: Creating Innovative Applications and Devices*. New Riders.

Schlinger Jr, H. D. 2010. “Theory of Mind: An Overview and Behavioral Perspective.” *The Psychological Record* 59 (3): 7.

Schreibman, L. E. 2005. *The Science and Fiction of Autism*. Harvard Univ Pr.

Shah, Nirvi. 2011. “Special Ed. Pupils Find Learning Tool In iPad Applications.” *Education Week* 30 (22): 1 –17.

Volkmar, Fred R. 1998. *Autism and Pervasive Developmental Disorders*. Cambridge University Press.

Wendt, Oliver. 2012. “The Places We’ll Go: Innovative Web App Helps Children With Autism.” *Case In Point* 10 (5): 24–25.

Westwood, Peter. 2007. *Commonsense Methods for Children with Special Educational Needs*. Routledge.

White, Susan Williams, Kathleen Keonig, and Lawrence Scahill. 2007. “Social Skills Development in Children with Autism Spectrum Disorders: A Review of the Intervention Research.” *Journal of Autism and Developmental Disorders* 37 (10) (November 1): 1858–1868. doi:10.1007/s10803-006-0320-x.

Yee, H.S.S. 2012. “Mobile Technology for Children with Autism Spectrum Disorder: Major Trends and Issues.” In *2012 IEEE Symposium on E-Learning, E-Management and E-Services (IS3e)*, 1–5. doi:10.1109/IS3e.2012.6414954.

# APPENDICES

# Appendix A. Design Document

Appendix A includes the design document for Literacy Labels.

Design Document for:

# Literacy LABELS



Written by Nancy Rasche

Version # 1.6
October 7, 2013
**Draft**

## Design History

The original draft of the document was written on January 25th 2013.

**Version 1.6**

Version 1.6 includes final graphic and interaction design for prototyping. The following changes were made:

1. Final graphic images were added.
2. Final interaction design flow was added.
3. Final design validated.
4. This is the sixth draft of the document.

**Version 1.5**

Version 1.5 includes some revisions based on feedback from the visual mockup review. The following changes were made:

1. Mock-up images were added for clarification.
2. Play flow of *Seek and Find* mode was updated to include "teaching" of correct answer.
3. This is the fifth draft of the document.

**Version 1.4**

Version 1.5 includes some revisions based on changes in the design intent. The following changes were made:

1. Mock-up was created for review.
2. This is the fourth draft of the document.

**Version 1.3**

Version 1.3 includes some revisions based on changes in the design intent and production timeline. The following changes were made:

1. Design goals were revised to incorporate the addition of an imbedded QR code generator and decoder versus the earlier version that needed wi-fi.
2. Addition of designer John Pourcho; interaction and layouts for printing and scanning
3. Addition of programmer Shaung Wei; prototype programming of play mode for testing.
4. This is the third draft of the document.

# Game Overview

**Vision Statement**

Would students with autism, who learned to communicate with the PECS symbol cards, benefit from using emergent literacy labels where the written word dominates the symbol? Can this step in literacy development be supported on a touch screen mobile computer (iPad)?

Teaching the concept of the written word in real world context is very important for students with autism who are visual learners. Using labels for objects can be an effective tool for teachers and parents to convey to the child that all objects have a verbal name and written name.

For example: Putting a label on the door and pointing to it when entering or leaving a room can translate the permanence of that object's association to the written word. The real world understanding of the actual object can help to make this translation easier for the autistic child.

**Philosophy**

*Literacy LABELS* is an educational game for students with autism who are ready to bridge into reading and need extra support of the understanding that all objects have a verbal name and a written name. The intent of the game is to reinforce the skills being taught by the labels in the home or school environment. The iPad is very effective in allowing for repetition and consistency in learning skills. It can provide a support system for learning. This game will focus on the home environment where the child most readily knows the objects. There will be five rooms with four leveled activities for each room. Each room will have a progress bar and animations for correct answers by a chosen friend (friends are household pets: Hamster, Dog or Cat). The amount of progress steps and difficulty of activities will be customizable by the user.

The games are designed for the purpose of supporting the use of actual labels in the home environment. This game aspect of the learning process must be fun and enjoyable to the user. As it reinforces the skills and improves retention, it must also be entertaining to the user with rewards based on set goals.

The basic flow of the game is similar to most educational games and therefore should be easy to pick up by the general user. Most children with autism will require a facilitator to model the behavior. The goal is to have the easiest play mode be accessible to those who would need the most assistance.

The core benefits expected from this design practice are:

- **Game: Improved understanding that the written word is associated with the object and/or symbol**

By putting the focus on the written word, we are trying to bridge toward reading and writing. Labeling objects is an early literacy skill that is used in many typical development preschool and kindergarten classrooms. Using this principle with autistic children, who learned to speak using the Picture Exchange system, should help them bridge toward reading and writing.


*Fig. 1 Home page*

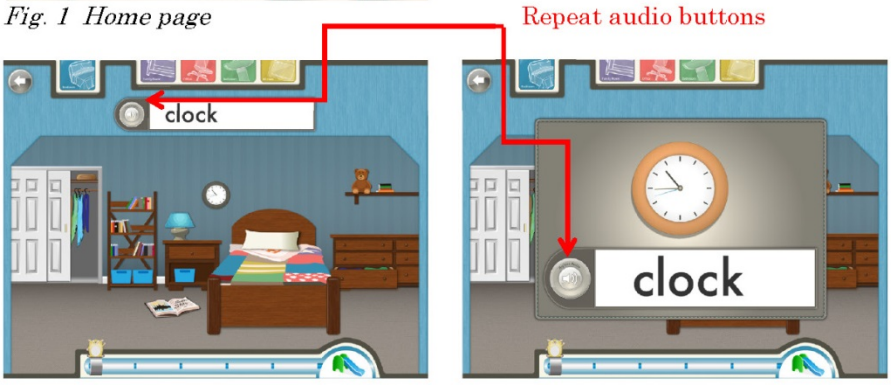


*Fig. 2 Seek and Find mode* *Fig. 3 Label popup with animation*

- **Printed Physical Labels: Print labels that are within the game**

By using the context of the actual object, it is easier for children with autism to associate the meaning. The application will provide all the labels that are used in the application so that they can be placed on the actual objects in the home.

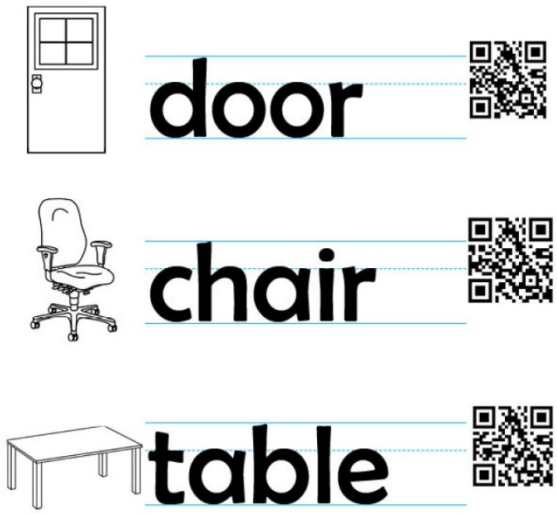


*Fig. 4 Example of Physical Labels*

- **Customized Physical Labels: Create custom labels**

The user may create their own labels for objects that they would like to work on. The application will provide link to

ADD SYMBOL: choose existing image from library or take photo
ADD LABEL NAME: keyboard to enter name of object
ADD QR CODE: choose existing from QR library or create new QR code with computer voice or user-recorded voice

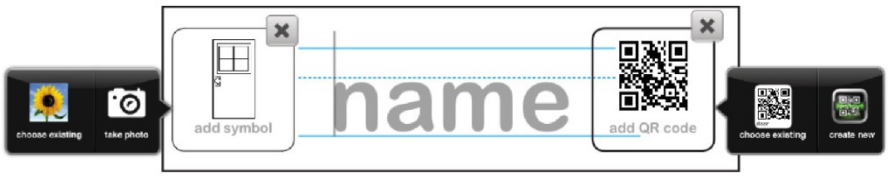


*Fig. 5 Example of creating custom QR code labels*

- **Scan Labels: Scanner in application**

The application will have an internal scanner that will use the iPad's camera and will not require a wi-fi connection. This scanner will allow the user to scan any of the physical labels to hear their name spoken. They can also be created with instructions.

Example:
"Window… Can you say window?"
"Chair… Chair is spelled C.. H.. A.. I.. R."
All of the auditory labels can be repeated many times for reinforcement by the scanner with in the game.

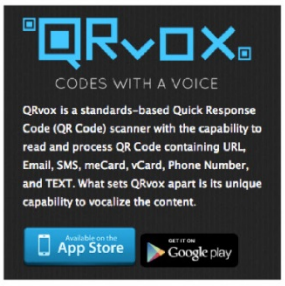



*Fig. 6 Example of free QR scanner* *Fig. 7 Scanning with Literacy LABELS*

By embedding the QR creator and decoder the iPad or any mobile device can provide the auditory name of each label for those who need extra help.

## Common Questions

**What is the game?**

*Literacy LABELS* is an educational game based on the early literacy teaching skill of labeling objects with their written name. This skill reinforces the concept that all objects have a written name. The game is intended to support the real world application of labeling objects in the home. It supports the difficulties that many students with autism have with speech delays by providing a scanner to provide auditory name for each label with the QR code.

*Literacy LABELS* is a language skill game for autistic students. The students should have a basic understanding of the symbol based language system (PECS) and the navigation of iPad applications. A facilitator will be needed to model the basic game flow for some of the students.

**Why create this game?**

*Literacy LABELS* is intended to bridge from Picture and Symbol language systems to emergent literacy skills. It is not intended to teach the child to read, but to prepare them for reading by teaching them that all verbal objects have a written name. The emphasis is on fun and education together.

**Where does the game take place?**

The game takes place in the home. The reason for this is that the home is filled with readily understood objects. Also the physical labels can be placed in the home. The application is meant to reinforce the skills being taught by the physical labels.

**What is the main focus?**

**Game Play**
The player aims to fill their reward bar with correct answers with in all of the activities. With each full chart they receive a new food item, toy, or accessory for their friend. The goal is to collect all the rewards for their friend. Once they have collected all the rewards for one friend, they can repeat the game again for another friend. For example, after finishing with the hamster, the

student can repeat the game with the cat. This allows for repetition and the ability to increase difficulty if possible.

**Education**

The educational goal of the game is to improve the autistic student's understanding that all objects have a written word. The association of the orthography of the word with the actual object in context is imperative to facilitate vocabulary learning based on meaning. This will improve comprehension which is a difficult skill for the autistic learner who tends to have strong decoding skills that lack meaning. The application will have two instructional modes: Scanning the physical labels and playing the game to reinforce the skills. When playing the game, the user chooses between four skill levels. They can explore labels, seek and find, match the label and/or pick the first letter. The goal is to learn the labels and fill the reward bar. Animations and rewards will encourage correct behavior and the completion of tasks.


*Fig. 8 Four play modes*

**What are the Educational Methodologies?**

This game reinforces the emergent literacy skill of using labels to associate the orthography with the actual object. This is also intended to extend vocabulary and improve comprehension. The game uses a simple *exploration* mode, a *seek and find* mode, a *matching* of labels mode and a *find the first letter* mode.

## Feature Set

**General Features**

- **Educational experience**
  The games primary focus is to introduce the player to the emergent literacy concept of the association of the written word with the object in a context that is familiar to the student.
- **Playful experience**
  The addition of the friends will make the game more fun and entertaining. The friends can also give clues and help with in the play mode.
- **Reward incentives**
  The rewards are meant to motivate the player to want to get correct answers. They are meant to be playful and fun.
- **Game environment emulates learning in real world**
  The game environment is meant to represent the learning experience in the real home. The use of actual physical labels in the home is imperative for the goals of emergent literacy to work for students with autism.

## The Game Play Modes

**1). EXPLORATION MODE: Simple touch, see, and hear labels**

OVERVIEW: Lowest difficulty: This is the starting gameplay that is a simple touch and explore mode.

The student will simply explore the object labels by touching them. When the objects are selected the label opens. The audio of the label is played and a bar is added to the reward tracker. This would be an introduction to the game in its easiest play mode with the goal of explaining the play flow with **no incorrect answers**.

TASK: When entering a room, the player receives the task.
The chosen friend says, "Explore 5 labels to get me a new Hat." The progress bar will show 5 empty spaces with the reward at the top. The task is completed when the goal is achieved.

REWARD: A reward is given for each exploration of a label. When a object is touched, the label will open. A short animation of their friend saying "Wa-hoo!" or "Way to go!" will play. A reward will be placed in the progress bar.

PLAY FLOW: The student enters a room and explores the labels by touching and opening them. REWARDS are given. The label audio will play and it can be repeated for reinforcement by hitting the repeat button on the label. After a label has been explored it will reduce transparency in the room and cannot be accessed again until the user exits and returns to the room. This will encourage the exploration of all the other labels in the room.

**2). SEEK AND FIND MODE: Understanding that the object label**

OVERVIEW: Middle difficulty: Encourages the student to listen for the prompt and touch the correct object. This is the first step in the play mode that tests the learning of the labels. The application will provide a written and an audio prompt. The Seek and Find mode will require that the player have an understanding of the objects and labels in the rooms.

TASK: When entering a room, the player receives the task.

The chosen friend says, "Get 5 correct to win me a new Hat." The progress bar will show 5 empty spaces with the reward at the top. The task is completed when the goal is achieved.

REWARD: A reward is given for correct answers. Same as Exploration Mode.

PLAY FLOW:

REWARD: Friend announces reward item. Example: "I'd love a new slide!"

SCREEN LOCK while prompt is read. Locking the screen will the prompt is being read will help the autistic learners to listen to prompt. Prompt: "Clock. Touch the clock." The audio prompt can be repeated as necessary.


SCREEN UNLOCKS


Correct:
LABEL POPUP SCREEN


Animation of FRIEND plays (Wa-hoo, Way to go! You got it! Or Yippee!...)


Animation of CLOCK plays: "Tick, tock, its almost 11 o'clock." LABEL is read: "Clock. C-l-o-c-k. Clock" The audio of label can be repeated as necessary.


PLAY AGAIN button appears to RETURN to room. If button is not pressed in 5 seconds, the game will automatically return to the room.

REWARD animation fills in one bar on the progress tracker.

*INCORRECT RESPONSES*
Incorrect object that was touched will reduce transparency.
Repeat prompt.

Incorrect 2nd try: Incorrect object that was touched will reduce transparency, if not already.
Correct OBJECT will highlight and enlarge.
Repeat prompt.

Incorrect 3rd try: Incorrect object that is selected will reduce transparency, if not already.
Correct OBJECT will highlight and enlarge.
No reward.
NEW prompt.

Will continue until 5 correct answers are made or player exits play mode.

**3). MATCH THE LABEL MODE: Choosing the correct label for the object**

OVERVIEW: Advanced difficulty: This mode requires the user to place the label with an object from 3 choices. The goal is to learn that labels match the object. The student will need to place the correct label with the object. The Match mode will required that the player have a basic understanding of the objects and their names.

TASK: When entering a room, the player receives the task.
The chosen friend says, "Get 5 correct to win me a new Car." The progress bar will show 5 empty spaces with the reward at the top. The task is completed when the goal is achieved.

REWARD: A reward is given for correct placement of the label. Same as Seek and Find Mode.

PLAY FLOW:
Object appears with three labels next to it.
PROMPT: "Touch the label for book."

Correct: Label opens, friend animation plays (Wa-hoo) and one bar is filled in on the progress tracker.

Label audio is played.
"Lets Play Again"
RETURN to room: Next object appears with three labels next to it.

Incorrect: Incorrect label audio is heard. Object highlights and correct audio is heard. Incorrect label is reduced in transparency.
Repeat PROMPT: "Touch the label for book."

Incorrect 2nd try: Object highlights and correct audio is heard.
RETURN to room with new object and prompt.

**4). FIRST LETTER MODE: Choosing the correct first letter of the label**

OVERVIEW: Advanced difficulty: This mode requires the user to place the beginning letter on the label from 2 choices. The goal is to learn that letters make sounds and those sounds make up words. Touching the letter will give the sound. The goal is to place the correct letter at the beginning of the word on the label. The First Letter mode will require that the player has a basic understanding of the objects and the labels.

TASK: When entering a room, the player receives the task.
The chosen friend says, "Get 5 correct to win me a cupcake." Progress bar shows 5 empty spaces with the reward at the top. Task is completed when the goal is achieved.

REWARD: A reward is given for correct placement of the letter on the label. Same as Seek and Find Mode.

PLAY FLOW:
Object and label opens with missing first letter. Two letters are displayed.

PROMPT: "Touch the first letter for book."
Correct: Letter fills in empty first letter space, friend animation plays (Wa-hoo) and one bar is filled in on the progress tracker. Label audio is played.
"Lets Play Again"
RETURN to room and new object and label opens with missing first letter.
Incorrect: Incorrect letter audio is heard. Object highlights and correct letter and label audio is heard. Incorrect letter is reduced in transparency.

Repeat PROMPT: "Touch the first letter for book."

Incorrect 2nd try: Object highlights and correct letter and label audio is heard.
RETURN to room with new prompt.

# Game Environment

## Overview

The game is designed to support the use of the physical labels that are used in the home. We strived to make a generic looking living area so that the objects are not being learned by color or shape, but by the actual label of the object. Eventually, the game could be expanded to other occupational therapy areas for the student. Such as, the grocery, the classroom, the park, etc.

## Room Specifics

There will be 5 rooms: Family room, bedroom, bathroom, kitchen and office. Each room will have 10 active items with one interactive item (picture frame, game, book, etc.)


*Fig. 9 The 5 rooms*

# Game Friends

**Overview**

The player can choose between 3 different friends. The options will be household pets; hamster, cat or dog. The friends provide incentive to play the game. The player will need to complete tasks to win items for their pet. Each pet will have a total of 20 possible items to achieve. Once they are achieved, the user can choose another pet and repeat the game up to 3 times. If they wish to repeat the game again after the three pets are done, they can create a new user name and start over.


*Fig. 10 3 Friends*

**Friend Rewards**

The player will receive rewards as items for their friend based on their achievement of goals.

Task rewards could include:

- Clothing: Hat, backpack, sunglasses...
- Food: water, hotdogs, donuts...
- Toys: car, ball and bat, mouse...
- Housing: Hammock, Cabana, tree house...


*Fig. 11 Friend room, animation*

All rewards will have an audio response and a label. Some of the rewards will have an animation. For example: "Awesome car, Vroom...Vroom!" The friend will ride the car over the hill and the label will be up the entire time. At the end of the animation, the label will be read, "Car. C-a-r. Car."


*Fig. 12 Friend room, no animation*

If there is no animation, the label will appear and the friend will say something related to the item. For example, "Cool sunglasses!" Then the label will be read, "Glasses. G-l-a-s-s-e-s. Glasses."

## Single-Player Game

**Overview**
The game is only designed for a single player. Gameplay is designed to encourage short informative lessons of game play. A game play session will last between 10-20 minutes. Player information will be stored to be available the next time they play. This information will also be accessible by the facilitator (teacher or parent) to check the player's progress.

Each game play experience will be randomized between prompts. The player will have reasonable variety in each room, even if it is repeated. The order of question will change each time.

The preferences screen will allow for the choice of a locked or unlocked screen. A locked screen will not let the players leave a room until the task has been completed. While an unlocked screen, will allow the players to move from room to room.

**User Profiles**
The game requires the user to set up a profile. There can be multiple user profiles saved with in the application. Each profile is saved at exit and is accessible during start up. This allows for the user to build upon their previous work. It also allows for teachers to view the progress that a student has made.

**Story**
The game does not have a pre-set story, but the aspect of collecting rewards for their friend will create its own story line.

**Hours of Gameplay**
Total gameplay will be between 1-5 hours for each set of rewards.

**End Conditions**
The game's end condition would be the completion of all the rewards for a pet and/or an understanding of the meaning of all the words. Depending on the learner, the understanding of the words will occur at varying level of repetition. The game can be repeated for each one of the pets. Therefore, the game can be repeated a total of three times with varying level of difficulty for each. For example, the game can be completed entirely in the explore mode or in a combination of any of the four play modes. The game can also be reset, to start over by creating a new player profile.

# Coding

**Overview**

The prototype will be coded in Flash Action Script for testing and evaluation purposes only. The final coding will be done in x-code to make it compatible with the iPad.

Prototyping will consist of one room in Seek and Find mode for evaluation. The label creator and scanner will also be prototyped in Flash Action Script. The scanner will need to be tested to evaluate usability.

## Appendix B. Blank DOC and User Persona

Appendix B contains the blank DOC.

# Definition Outline for Collaboration (DOC)

**Application Name:** _____

**Design Intent:** _____

_____

_____

**Name:** _____

**Contact Info:** _____

**Date:** _____

## **Who?** *Creating the User Persona*

*Who are the users: background, abilities, needs and goals?* Create a basic universal example of the user.

_____

_____

_____

_____

_____

## **Why?** *Identifying necessity*

*Why is this pedagogy used and is this application design necessary?* List benefits of automation in mobile application and define research into similar applications on the market.

Need:_____

_____

_____

_____

Market:_____

_____

_____

**How?** *Method of Implementation*

*How will this skill be currently implemented?* Explain pedagogy for the skill.
*How can it be implemented in a mobile application?* Detail use for mobile application.

Direct instruction:_____

_____

_____

Application:_____

_____

_____

_____

**What?** *Application purpose*

*What are the goals? Purpose and completion goal for the application.*

Purpose:_____

_____

_____

Requirements:_____

_____

_____

Completion-goal:_____

**Where?** *TSMC and Application use*

*Where will the TSMC be used? Define the environment and use of the application.*

Environment:_____

_____

_____

Usability:_____

_____

_____

Name: _____ Contact Information: _____

Profession: _____ _____

## *User Persona*

Persona: Name representative user.

Application Design Intent: What do you plan to achieve?

Background Information: Explain users development.

Instructional Needs: Explain users educational requirements.

### *Current Skill Instruction:*

Provide any examples

### *Application Design:*

Ideas or related apps