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# Evaluation of sign language learning tools: Understanding features for improved collaboration and communication between a parent and a child

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**Evaluation of sign language learning tools: Understanding features for improved collaboration and communication between a parent and a child**

by

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A thesis submitted to the graduate faculty  
in partial fulfillment of the requirements for the degree of  
MASTER OF SCIENCE

Major: Human Computer Interaction

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## ABSTRACT

Deaf children with hearing parents typically have issues with learning sign language fluently and developing literacy. In addition, these children rarely establish a strong, interpersonal bond with their caregiver. Currently, there are insufficient resources for helping bridge the gap between deaf children and hearing caregivers. This thesis proposes to explore solutions and evaluate their effectiveness with both the hearing parents and deaf children. Multiple mediums are investigated for the purposes of uncovering the most effective combination of sign language learning methodologies. This research will help designers better understand the world of deafness and how to design instructional tools that effectively utilize information about the needs and customs of the Deaf community.

## CHAPTER 1

### Problem Statement

Deaf and hard of hearing children face many more unique challenges with language comprehension than hearing peers. The deaf are severely restricted from social interactions. To participate in social venues, deaf individuals must be able to communicate through a method such as lip reading or learning sign language. Without a form of communicating with others, a deaf individual could potentially be cut off from healthy social relationships. Two to three out of 1000 children are born deaf in the United States. At least 90% of these children are born to parents who are both hearing (National Institute on Deafness, 2010). Some hearing parents have the means of adopting non-auditory forms of communication but most parents lack both the skills and resources to communicate effectively with their deaf and hard-of-hearing children (Mayer, C., 2007). This situation is further complicated by some children being raised in communities where deafness is associated with a disability, and a parent may assume that the child may not be able to measure up with other students and will not be able to live independently. The parent will assume the child's deafness is a disability, and may not give the child adequate resources for further development. This lack of communication results with the deaf child not having appropriate development of language and literary abilities that are comparable to hearing peers. These negative impacts extend to the hearing parents, with hearing caregivers expressing feelings of failure or sorrow about a child's deafness and misrepresenting the child's deafness as a handicap (Meadow, K.P., 2007) which further perpetuates the problem. As shown in Figure 1, there is a wide range of familial structures related to traits of deafness. The scope of the thesis will focus mainly on the role of hearing parents with deaf children.



*Figure 1 This grouping demonstrates the diverse family structures that involve hearing caregivers and deaf children. This is just a sample of the many types of familial structures. Please note that this figure does not include hard of hearing children or*

Early literary development, such as reading and familiarity with written language, for deaf children is very important. The deficiency of these skills results in limited social engagement with peers or family members, negative interfamilial perceptions, emotional immaturity and increased dependence on parents (Vaccari, C. and Marschark, M., 1997), low language competency and a combination of socio-emotional, cognitive, and linguistic impairments (Mayer C. 2007; Vaccari, C. and Marschark, M., 1997; Meadow, K.P., 1980). Surprisingly, these deficits do not extend to deaf and hard-of-hearing children raised in a familial environment where both parents are deaf. Deaf parents communicate with their deaf children using sign language from a very early age, resulting in increased linguistic aptitude and greater understanding of appropriate social cues (Vaccari, C. and Marschark, M., 1997). The comparison of deaf children with hearing parents and deaf children with deaf parents is insightful since it



presents clear evidence that deaf and hard-of-hearing children can develop normal linguistic skills given simple but crucial information of early childhood dialogue through the use of sign language. So the main issues of communication arise when a deaf child is born to both hearing parents. Please note that there is not a gold standard for the best method to teaching a deaf child sign language. Learning can vary based on whether the child will receive cochlear implants, is hard of hearing or completely deaf, and how the family adjusts to hearing loss (Cicourel, A. V., 1972, Marschark, M., 1997, Stokoe, W.C., 2005). Even the type of sign language chosen may influence the best way to teach a young child (Stokoe, W.C., 2005).

This paper aims to present tactics for designing a language learning system for deaf children. The primary purpose of this study is to evaluate three common types of instructional tools that are used to teach sign language to hearing parents and deaf or hard of hearing children. The overall design of the tool may have been designed with different audiences in mind, but certain pieces of the tools that directly target hearing parents and/or deaf or hard of hearing children were used for evaluation. The evaluation of these tools will provide guidance on good design tactics for a language learning system for deaf and hard of hearing children. The thesis illustrates the cultural nuances of the deaf community and how sensitive to those differences are regionally in the United States and in other countries. Through a heightened understanding of the culture, deafness, the stigma experienced from early childhood, the interpersonal relationships of the deaf person with his or her community, and the technological solutions that benefit that deaf child's circumstances, this thesis provides a fresh outlook on how to better teach deaf children born to hearing parents with language learning technologies. The importance of this topic, is to help designers better understand the world of deafness and to be unbiased in regards to Deaf culture and other elements related to deafness. Increased awareness of the deaf world and the

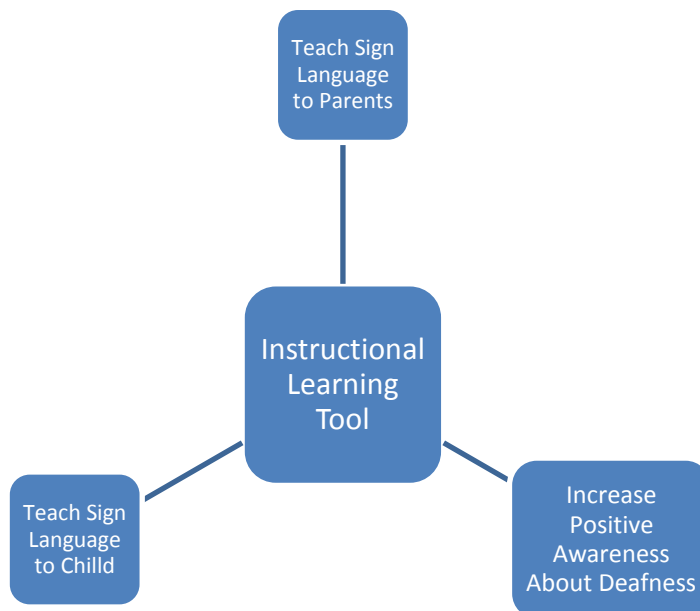
challenges faced by this community are integral to successfully designing a system to help with language learning for both the deaf child and the hearing parent.

Ultimately the thesis aims to answer the following three questions:

1. What are the design requirements for a language learning system for deaf children and their hearing parent?
2. What technological solutions adequately address both the social and linguistic needs of deaf children and hearing parents?
3. How can a language learning tool help a parent and child not only communicate, but connect?

Presented first is the topic of deafness and how deaf individuals view their own deafness. It may not be a surprise to some that deaf individuals have their own culture and language. Much of the Deaf community fights for others to understand that they do not view their deafness as a disability or something that should be changed. Members of the community fervently describe that they can be very happy and still have a sense of purpose and meaning in their lives, without the ability to hear (Sparrow, 2005). Deaf individuals can even be offended at the suggestion to fix their deafness. Furthermore, deaf individuals would not trade their deafness for hearing and will even be very happy if his or her child is born deaf, clearly suggesting that deafness is just another way of life, not an impairment that needs to be cured or modified (Sparrow, 2005). It is true that, deaf individuals may face difficulties due to their lack of hearing, but that is primarily a reflection of society and not the individual lacking the means to hear (Sparrow, 2005). In the past, deaf individuals faced tremendous challenges due to issues such as ethnicity, nationality, sex, or physical impairment (i.e., losing a leg or arm), level of intelligence, height, or sexual orientation but these challenges have been mitigated due to societal changes. This paper suggests

one positive change that can be implemented in the Deaf community. By helping young deaf children and hearing parents learn sign language shortly after the child's birth and informing the parent of the Deaf community, language learning technologies may help the child learn sign language successfully and develop positive social relationships with his or her family members. Figure 2 shows a diagram of how a language learning tool could be utilized. While the attitudes of deafness can be controversial, this research assumes that the goal of a tool is to introduce Deafness and Deaf culture with a more positive approach. Research shows (Vaccari, C. and Marschark, M., 1997) that families who embrace deafness and Deaf culture may have a positive impact on the child.



*Figure 2 Instructional learning tools may need to incorporate the features of teaching sign language to parents and to the child as well as increasing positive awareness about deafness. The thesis will focus on these top level elements when discussing an*

## Author Bias

Please note that the author of this paper is not a member of the Deaf community and is hearing. This thesis is written from the perspective of an observer and much of my insight is from prior research and interviews from individuals involved to at least some degree in the Deaf community. Before discussing this paper, I must also explain terminology that will be used throughout this paper. When speaking about the Deaf culture, Deaf with a capital “D” will be used, while deaf with a lowercase “d” will be used for 1) individuals who are deaf but do not identify themselves as member of the Deaf community or 2) describe the lack of hearing that an individual has. The only sign language that I will be discussing is American Sign Language (ASL) since that is the language used primarily in the American Deaf community.

To better clarify this complex topic, I have divided Chapter 2 into multiple sections. The first section will introduce the Deaf and hard-of-hearing community. It will describe the issues that individuals born deaf have to face from early childhood and onwards. This section will provide relevant factual information to better introduce this topic.

The second section will describe sign language, particularly American Sign Language (ASL). An understanding of sign language and the history of ASL is integral for beginning to think about designing a system teaching the fundamentals of sign language. This section on ASL will not be exhaustive but will provide a brief and comprehensive description of the language and aspects to consider for design.

The third section will discuss research on the interaction of hearing parents with deaf children. This section will focus on defining the specific issues a hearing parent and deaf child may face, and the negative consequences that both may undergo. Section four will discuss literacy and word-learning strategies. An understanding of literacy and how it’s taught is

essential for understanding some of the goals of a successful language-learning technology. Being able to comprehend how literacy is achieved throughout early childhood will lead to increased understanding of the process children must go through to learn. Research of word-learning strategies will also be discussed to better understand what strategies have been shown to be successful with deaf children compared to hearing children. Understanding these word-learning strategies is crucial to ensuring that a language-learning tool will incorporate many of those strategies.

The fifth section will discuss variables for measuring achievement. This section will help refine some of the goals for understanding how a child performs well, and how to measure that achievement successfully. The sixth section will discuss language-learning tools available for both hearing parents and deaf children. The section will primarily discuss some of the drawbacks and strengths of each tool.

*Table 1* This table shows the various sections of Chapter 2 and a brief description about the sections.

<b>Sections of Chapter Two</b>	<b>Description</b>
Section 1: Components for Consideration for Educational Software	Defines and clarifies some essential components to consider when designing an educational software tool.
Section 2: Deaf and hard of hearing Community	Describes issues that this community will face
Section 3: Sign Language	Provides definitions and descriptions of sign language, particularly American Sign Language (ASL)
Section 4: Importance of Technological Applications in the Deaf Community	Provides a description of the importance of technology in the Deaf community and how it is utilized
Section 5: Impacts of Technology Utilized as a Teaching Tool for ASL	Will discuss how technology is specifically utilized when teaching ASL.
Section 6: Tactics for Teaching ASL to Parents	This section discusses some of the methodology of how ASL is taught to parents specifically.

Section 7: Creation of SignBright	This section discusses how SignBright was created and the steps the author took to create the prototype.
Section 8: Word-learning Strategies Useful for Deaf Children	Will define literacy and how research has shown literacy is achieved. Word-learning strategies successful with deaf and hard-of-hearing children will be discussed.
Section 9: Variables Influencing Achievement	The focus is on defining achievement and the various achievement goals throughout early childhood. Lastly, the influences of other variables on achievement such as SES or ethnicity.
Section 10: Current Instructional Tools for Children	Language-learning tools used for deaf children and/or hearing parents will be discussed, as well as some of the strengths and weaknesses of each tool.

The third chapter will focus on the experiment conducted. The chapter will be broken into sections about the methodology, procedures and general design of the experiment. The fourth chapter will discuss the results of the study and how these results should be interpreted. A discussion will be provided on these results.

## CHAPTER 2

The following chapter will provide an overview of research related to deaf and hard of hearing children and how they learn sign language. Multiple variables will be assessed such as word learning strategies, achievement variables and sign language. This chapter will discuss instructional tools that are currently being used.

### Components for Consideration for Educational Software

The following section describes various attributes that are important when designing educational software for the deaf and hard of hearing population. Figure 3 shows the components that will be discussed later in the paper.



*Figure 3 Summary of attributes for consideration when designing educational software for the deaf and hard of hearing populace (DeLoache, J.S., 2010, Malone, T.W., 1987, Sparrow, 2005, Quinne, C. 2005).*

## Age

One may wonder what ages a language learning system should focus on. This research focuses primarily on teaching ASL to younger deaf and hard of hearing children. Research (Houston, D.M., and Richard T.M., 2012) has shown that ASL can be learned throughout early childhood and beyond. Unfortunately, designers may overlook the inability of infants to learn via software. Parents and designers may overestimate their child's abilities and assume that their infant can learn language through media. With the rapid development a child undergoes, this misconception is easily understandable. A child may be learning through various methods, and a



parent may inaccurately attribute that learning to software or some other type of media. The designer, however, must understand how learning can occur during infancy to better market the software appropriately. Recent research suggests that children between the ages of twelve to eighteen months fail to use information shown via symbolic media (DeLoache, J.S., Chiong, C., Sherman, K., Islam, N., Vanderborght, Troseth, G.L., Strouse, G.A., and O'Doherty, K., 2010). This is particularly useful information when considering the importance of parent and child interaction throughout the early years of development. When a child is about eighteen months old, videos of characters using ASL may become useful to a child. Until then, the software should aim at teaching parents ASL to help guide their children to learn sign language effectively. Parents can teach their young children ASL prior to twelve months, but fluency is not expected for a parent at this stage. Research (Houston, D.M., and Richard T.M., 2012) states that children as young as six months can learn babbling and basic commands in ASL, such as “milk.”

The system should also provide assistance to the parent. The parent will be the one making the decision to use the software and will be the gateway for the child to use the system. Assuming the parent has no knowledge of sign language, research suggests that the success rate of parents adequately learning sign language is significantly lower than the success rate of their child trying to learn sign language. The parent will also need the system to teach them as well. A system aimed at teaching both the child and adult will have a higher likelihood of ensuring that the child will have good support for learning sign language. The system should not be the primary way for the adult to learn sign language. An adult may have a variety of obstructions, including time constraints, varied learning times, and cultural biases, preventing them from successfully using a tool for fluency. The tool should be a great way to introduce an adult to sign language, become acquainted with the system his or her child is using, monitor his or her child's

progress, and continue to be involved with the child learning language. The role of the caretaker is imperative for a child to eventually obtain mastery of sign language. The parent must aim to be part of this process and to continue their own personal mastery of the language outside of the system, whether that is by taking a class or hiring a personal teacher. Regardless of this, the goal of the system in regard to the parent should be to increase the motivation of the parent, allows the parent to be an active role in the language learning process, and foster understanding and bonding between both the parent and child.

## Fun

Thomas W. Malone (1987) theorized that fun was an important element in educational software. Software may have instructional value for a user, but unless the software is captivating, that instructional value may be lost. Educational software may be ineffective if the user lacks motivation to complete particular objectives with that software. Users may already lack motivation to learn the subject the software is attempting to teach. Therefore the goal of the software will be to enable the user to feel excited about the subject. According to Malone, the characteristics an engaging atmosphere include challenge, fantasy, and curiosity. However, engagement does not necessarily lead to an item being perceived as fun. According to prior research (Dix, 2003) there have been paper-based tests that have been shown to be engaging towards users but are still not perceived as fun. In other words, designers should account for fun and consider elements such as challenge, fantasy, and curiosity, while realizing that these alone do not necessarily lead to something being perceived as fun.

## Challenge

A language learning system should be challenging (Malone, 1987, Csikszentmihalyi, 1988, Quinne, C. 2005). Clearly a system lacking in challenge will send a message to the user

that the software is useless. Lacking difficulty may result in initial interest, but inevitable boredom. Alternatively, a system unreasonably difficult will quickly discourage use of the system but may unintentionally foster negative feelings of helplessness and maladaptive thoughts in the user. The system should continually adapt to the user's skill level, adjusting for the failures and successes of the user.

The system should have a clear goal (Malone, 1987). An unclear goal can easily confuse a user or result in frustration if a user is using the system incorrectly. Whether the device is encouraging the user to finish going through a story simulation or defeat a boss, the goal must be clear. Once the goal has been achieved, that also should be clear to the user. Feedback about the user's performance should also be provided. If the user is making a mistake, that should be conveyed. If the user is doing particularly well at a task, then positive feedback should be given.

To further increase the challenge, the system should consider ways to present obstacles to the user. One common method is by providing multiple levels or score keeping. As a user advances past a level, the next level may be more difficult. Scores may also be provided showing how well the user is doing in a particular level. Another common tactic for challenge is having variable difficulty levels. For example, a user may need to solve a puzzle that requires specific knowledge of ASL. After the puzzle is completed, a user may have to perform more advanced interactions in ASL.

## Fantasy

Fantasy (Malone, 1987) should be an element of a language learning system. Having emotionally appealing fantasies may be necessary for the user to have fun. Fantasy adds personality to a system and helps meet the emotional needs of the user. StarCraft and World of Warcraft are excellent examples of games that employ elements of fantasy to increase the

enjoyment of the user. A language learning system aimed towards meeting the needs of both young children and parents should contain fantasy elements appropriate for young children that are also enjoyable for adults. Perhaps a mixture of elements for both target audiences would be ideal to satisfy the needs of these two types of users.

An appropriate solution should expose children to relevant forms of language, including sign language and written forms of language, during early developmental stages (Stokoe, 2001). The solution should also incorporate various techniques to promote acquisition of language skills in a clear and engaging manner, since the language-learning process is unique to each user and can be frustrating (Marsharck, 1993).

## Storytelling

One component of a system designed for young children should be the element of storytelling, whether it is imposed by the developer or created by the user. Storytelling can be fun for a child and employs both creativity and the imagination. Storytelling also promotes interpersonal bonding with the child and parent, allowing for both to participate with the device simultaneously and share an experience together. Storytelling has been shown to promote mutual growth and understanding, help with learning linguistic skills, and enhance the bonds between child and caregiver (Peck, J., 1989). A number of child-centered studies (Peck, J., 1989, Egan, K., 1989., Bers, M.U., and Justine C., 1998) demonstrate the importance of storytelling and shared reading with parents. In early childhood, storytelling is well recognized as a means to support a child's development and to help a child express and assign meaning to the world. Storytelling also helps develop communication, recognition, and recall skills to enforce relationships with peers and adults (Peck, J.). Storytelling can be an important and intimate shared experience between a parent and child which fosters personal familiarity and

understanding. This paper proposes that storytelling may help to fill a crucial gap in interpersonal interaction between members of the target group since many hearing parents are unequipped to engage in active shared reading or storytelling with their children. Storytelling could also serve as a successful medium for creating a fun, motivational, and challenging environment for both the parent and child to learn sign language.

## Presentation

The system must incorporate a consistent method of how sign language will be visually taught to users (Ardito, C., et al, 2004, Johnson, J., 2010). Parents and children should be able to scan the information quickly for information (Johnson, J., 2010). Being able to actually see the sign correctly is also useful to the user. There would be limitations if the user had to carefully scrutinize visual information presented, since that may result in a lack of understanding (Johnson, J., 2010). Presentation of material involves both effectiveness and efficiency (Ardito, C., et al, 2004). Effectiveness may include that the tool helps support learning with the users, incorporates communication, contains some elements of personalization and is accessible to the user. Efficiency involves the structure being adequate. There has to be a way to tell what the system state is, a method for tracking progress, a visible course structure and ideally a way to adapt some features of the tool (i.e. allowing the user to increase the font size or to zoom into a picture) (Ardito, C., et al, 2004).

## Adaptability

The system must be adaptable to the user. Children may be at different cognitive levels, which age alone cannot not predict. Children also may have different perceptions about learning sign language. The parent primarily chooses the system, not the child. The parent may see the benefits of learning sign language, but the child may not clearly see those benefits, especially at a

young age. The system should be prepared to provide plenty of motivational features to get the child in the mode of wanting to learn sign language. The system should adapt to the rate that the child is learning. A child who is quick to learn and motivated will need additional challenges and tougher vocabulary. Children who are struggling may need the system to provide them with more review material and may need additional time to learn new vocabulary.

## Personalization

The system may want to incorporate some elements of personalization in the tool (Kramer, J, 2000). Kramer (2000) mentions that the primary focus should be on providing value to the end user, rather than deploying cool new features unwisely. A lack of personalization may result in the user finding the system to have less value or makes the user feel more likely to be disinterested in the system (Ardito, C., et al, 2004, Kramer, J, 2000). However, personalization can also harm the user if not employed correctly (Kramer, J, 2000). Any element of personalization should be tested and measured to ensure that the personalization is meeting the need of the user. This is integral to understand, since children or parents may require personalization when learning sign language. This may be an important feature to utilize if the system is meant to help the user learn beginning sign language to more advanced signs.

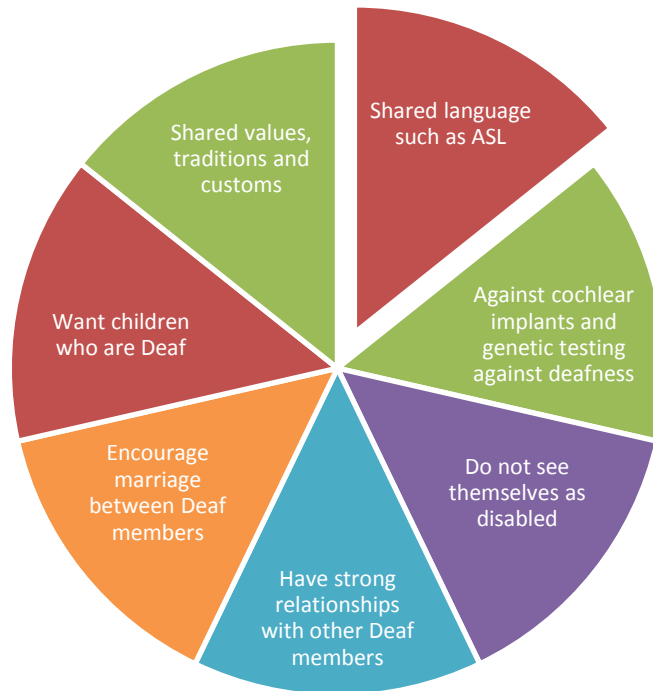
## User activity and feedback

Ideally the system should incorporate elements of measuring user activity (Ardito, C., et al, 2004). For instance, will there be an assessment test available for the user? How can the user manage their progress while learning sign language? More specifically, how can these tests be designed to be parent-friendly or child-friendly? Furthermore, are there methods for the user to quickly find information to reference? Some examples might include the index section in a book, how webpages may contain various links to related information, or a search box where the user

can type in a search term and get the appropriate term back. It's important to understand what questions the user may have throughout the process and to allow the tool, to easily communicate the solution to the user (Landay J.A., et al, 1995, Ardito, C., et al, 2004). The element of predicting user activity and feedback is an important component to consider when designing a tool.

## Deaf and Hard of Hearing Community

To better design for the younger deaf and hard of hearing populations, one must consider the role of culture in the Deaf community. Without being sensitive to both of these cultures, one may fail to create a system that is sensitive to the culture or risk creating a system that is potentially offensive to an individual or that negatively portrays the Deaf community. Creating a tool that is insensitive to Deaf culture may run the risk of driving away potential users and may foster negative impressions of the tool. Figure 4 provides a brief overview of the components necessary to be part of deaf culture. These components will be discussed in greater detail later in this section.



*Figure 4 This lists the necessary components for a deaf or hard of hearing individual to be considered a member of the Deaf community (Brooks, D., 1999, Schein J. D, 1989, Sparrow, R., 2005).*

First, let's discuss what Deaf culture is and how one becomes a member of this culture. Many may suspect that to be a member of Deaf culture just requires an individual to be deaf. However, this is not the case, and the integration into Deaf culture is far more complex and varies for each deaf individual. One deaf person may never discover Deaf culture or even have knowledge of its existence, while another may be integrated into the Deaf community from early childhood. As mentioned previously, the majority of deaf people are born to hearing parents and are immersed in the hearing culture initially (National Institute on Deafness, 2010). Many of these deaf individuals will be raised around hearing individuals and will be mainstreamed into schools where many may be just one of a few deaf pupils attending that school. A subset of these deaf individuals may rarely encounter Deaf culture and may not identify themselves as part of



Deaf culture or be completely unaware of what Deaf culture is. This is similar to what may occur with some adoptees who are adopted by a family of a different ethnicity; they may never identify themselves with the culture that they were initially born in (Brooks, D., Barth, R.P., Bussiere, A., & Patterson, G., 1999). These adoptees may know little to nothing about their ethnic culture.

Other deaf individuals may have their first experiences of Deaf culture while attending college and may enter Deaf culture at that time. A specific number may be difficult to gather due to the subjectivity of being a member of the Deaf community. In this circumstance, peer groups developed in college may introduce and encourage the deaf individual to participate in the Deaf community. Alternatively, some deaf people will be enrolled in specialized K-12 schools that cater to deaf individuals, resulting in these deaf individuals being immersed in Deaf culture from an early age. As a result, a significant amount of the deaf populace is not exposed to Deaf culture until after early childhood and may not develop a consistent method of communication until later stages throughout their lifetime.

Being born deaf or hard of hearing does not mean one is automatically part of the Deaf culture (Padden, C. and Humphries, T, 1988). Nor does hearing loss from an illness or accident or just general loss of hearing from aging qualify someone to become a member of the Deaf community. So what separates members of the Deaf community from other deaf individuals who are not part of that community? The qualities that members of the Deaf community share are that they all use sign language as a mode of communication, primarily ASL. Members of the Deaf community are typically from the United States and Canada. The Deaf community is not small, and the number of people in this community ranges from half a million to one million (Schein J. D, 1989). This community shares its own values, traditions and customs. Unlike other deaf individuals outside the Deaf community, the people in this group do not view their deafness as a

disability and are strongly against procedures such as the cochlear implant or genetic testing biased against deafness. Both are seen as a form of genocide in the Deaf community (Sparrow, R., 2005). Participants in Deaf culture tend to largely marry other deaf members and look forward to having deaf children.

Interestingly, the Deaf community has high expectations that a deaf individual will only marry another deaf individual. Deaf members value deaf children, and will devote a significant amount of time to helping a deaf child be part of the Deaf community. There are cases where Deaf members will travel long distances to ensure that a child feels accepted in the community. Deafness is not a stigma in this community and is something to be celebrated and encouraged. Just like any other culture, Deaf culture has its own rituals, distinct cultural constructs about how to interact with other members, rules, and language. Members have strong loyalty and bonds to other members living in the Deaf community. As Deaf members play successful roles in both the hearing and Deaf world, the community strongly encourages that Deaf members remember their role and importance in the Deaf community. Therefore, members are expected to remain involved in the Deaf community and will be encouraged to remain involved with other Deaf members regardless of current locale.

Similar to the hearing world, the Deaf community is a rich and unique community that has many ways to connect with its members. People in this community typically attend Deaf schools and Deaf colleges. Members in this community have their own creative arts that incorporate dancing, plays, and other artistic styles. Promoting deaf awareness through a variety of political means is highly important to this community. Furthermore, the Deaf community does view itself as a separate community from the hearing world. Many Deaf members believe that being Deaf should be classified as its own ethnicity. Designing an instructional tool must

understand how deafness is celebrated in the Deaf community. Being aware of the uniqueness of the community and how deafness is viewed can allow a designer to make a knowledgeable choice about how to present material, what avatars to choose in the tool, to avoid portraying deafness as a disability and to encourage users to learn sign language to not only communicate with the hearing world but the deaf world as well.

### Sensitivity to deaf culture

The language learning system must be sensitive to how it portrays deafness. The system should promote positivity for both the child and the parent. If the parent sees the system as a way to help their child with a disability, then the system has partially failed in its objective. The system should work to create feelings of awareness, acceptance, and support for their child's deafness.

When designing a system of this nature, the designer must be sensitive to some of the issues the Deaf community faces. The designer should be considerate that deafness is not a disability or something to be stigmatized. Many deaf individuals are fighting for the right to be viewed as their own ethnic group and not people who have a disability. The system should show deaf individuals as people. Deaf individuals are not people with a disability, nor are they people who always need additional help or support throughout their lifetimes. They are not individuals who are destined to live a limited lifestyle due to their inability to hear.

A language learning system should be sensitive to how children perceive themselves. It is very possible that a deaf child may not really understand his or her deafness in the context of the larger world. Children discover their deafness at different ages. There will also be large differences in the perceptions of deafness from child to child. One child may view their deafness as an illness, maybe prompted by close family members. Another child may not see their

deafness as unusual until much later when the child attends school. Another child may feel alienated from everyone he or she knows due to deafness. Each child should not be viewed as dealing with similar situations. The system should be sensitive what these children may be undergoing and aim to show deafness in a positive light and as something that can be shared and not hidden.

## Sign Language

My research necessitates understanding differences in sign language due to recognizing the importance and sensitivity of focusing on one form of sign language. Sign language is a form of communication used globally, amongst hearing, hard of hearing, and deaf populations. Sign language is not a universal language signed consistently in different geographic areas. Sign language is not a recent trend. There is evidence that speaking through gestures has been around since the beginnings of human civilization (Kyle, J. G., Woll, B., Pullen, G., & Maddix, F., 1988, Brentari, D., 1999). Different countries worldwide have different forms of sign language such as American Sign Language, Nicaraguan Sign Language, French Sign Language, and Puerto Rican Sign Language, to name a few. Figure 5 briefly summaries some of these languages used in North America, Central America and South America. Sign language is largely dependent on geography and has significant differences from other languages. It is essential to understand sign language when working with deaf children or adults and the families of those deaf individuals. Lack of understanding may result in significant challenges with understanding this community and may result in issues of miscommunication.

North America	Central America	South America
<ul style="list-style-type: none"> <li>• American Sign Language</li> <li>• Inuit Sign Language</li> <li>• Quebec Sign Language</li> <li>• Puerto Rican Sign Language</li> </ul>	<ul style="list-style-type: none"> <li>• Costa Rican Sign Language</li> <li>• Guatemalan Sign Language</li> <li>• Honduras Sign Language</li> <li>• Mayan Sign Language</li> <li>• Mexican Sign Language</li> <li>• Nicaraguan Sign Language</li> <li>• Panamanian Sign Language</li> <li>• Salvadorian Sign Language</li> <li>• Tijuana Sign Language</li> </ul>	<ul style="list-style-type: none"> <li>• Argentine Sign Language</li> <li>• Bolivian Sign Language</li> <li>• Brazilian Sign Language</li> <li>• Chilean Sign Language</li> <li>• Colombian Sign Language</li> <li>• Ecaudorian Sign Language</li> <li>• Paraguayan Sign Language</li> <li>• Peruvian Sign Language</li> <li>• Uruaguayan Sign Language</li> <li>• Venezuelan Sign Language</li> </ul>

*Figure 5 Sign Language in the Americas (Kyle, J. G., Woll, B., Pullen, G., & Maddix, F., 1988, Brentari, D., 1999)*

American Sign Language (ASL) is based on French Sign Language which was introduced to the United States by Thomas Hopkins Gallaudet. Although ASL is largely similar to French Sign Language, individuals who speak ASL are unable to effectively communicate with others who know French Sign Language. There are now so many discrepancies between the two languages that differences significantly outnumber similarities. Variations of ASL also exist. Although the signs used in ASL are similar when taught in a classroom setting, there are significant variations outside of that classroom context. Similarly to English which has unique variations between the English spoken in England, Ireland, rural North Dakota, or Georgia, there are distinct variations that have evolved in sign language (Stokoe, 2005). Black ASL is an excellent example of how ASL can differ amongst different communities. Black ASL developed due to racial segregation throughout the United States. To provide a brief background, many programs specifically catering to the Black Deaf community were mediocre. Many students

were not given the appropriate tools or teachers to learn sign language adequately. Many of the teachers were poorly trained and did not require any type of professional education to teach ASL to Black deaf students (Hairston & Smith, 1983). Black deaf people use a unique way of signing amongst their own social networks or in deaf clubs (Hairston & Smith, 1983). The use of Black ASL further intensified due to segregation, to the point that only Black deaf children could communicate with other Black deaf children. Their interaction in outside school activities such as sports resulted in new signs. When Black deaf children decided to speak Black ASL, the White deaf children were unable to understand those signs. At that time, society did not allow many opportunities for Black deaf and White deaf children to communicate, so the different forms of ASL further evolved and differentiated. This demonstrates the complexity of the usage of sign language within the Deaf community and how these differences are as sensitive as those in verbal language.

A common misconception is that sign language is merely a combination of hand and arm movements. Many might assume that using an appropriate arm movement will always have the same meaning regardless of other cues that a person conveys. Sign language consists of other gestures such as bodily movements, facial expressions, and even subtle shrugs. There can also be a lack of uniformity within sign language. There are many gestures that have different meanings depending on the orientation of the gesture. Sign language incorporates grammar, which means that the meaning of given gesture changes according to its placement and timing relative to other gestures. Simplistic ideas of sign language demonstrate a false belief that sign language lacks pertinent linguistic characteristics such as grammar. Sign language is not the equivalent of the spoken language in that geographic region. Many have the impression that ASL mirrors the spoken language of English, thus implying that sign language is created and based on a

commonly spoken language and not a language system that has developed independently. What may surprise many is how incongruent ASL is with spoken English. English is not directly translatable to ASL and vice versa. ASL actually contains all the fundamental features required for a language including its own grammar and nuances of how a gesture is performed. This is one of the reasons it is not uncommon for a deaf individual fluent in ASL to have tremendous difficulties learning written English.

These misunderstandings of sign language have very denigrating impacts and strong social implications for deaf students (Liddell, S.K., 2003, Stokoe, W.C., 2001). Members of the general populace sometime underestimate the knowledge of deaf learners and don't understand how these students may be able to communicate via sign language, yet have severe issues with written English. These misunderstandings may result in a deaf child being mislabeled as having a neurological impairment or prevent a deaf child from receiving the appropriate support to learn successfully. This lack of knowledge can further result in a child being discriminated against, viewed as unintelligent, and seen as incapable of performing even basic tasks. This can further the false belief that deaf individuals are born with cognitive impairments. Furthermore, lack of understanding may alienate the student and put the deaf learner in a situation where he or she may not have friends or only communicate with his or her caregivers and teacher. The child may end up being raised in an environment where maladaptive thoughts are more likely to occur due to the alienation by and misunderstandings of others (Stokoe, W.C., 2001, Erting, C.J., 1985).

Understanding sign language and its history is essential to designers developing a tool to teach the deaf and/or hearing populace. A parent should be given the knowledge that sign language is its own unique language.

How can learning ASL help to solve the problem of the deficits many deaf children may

experience? There are a variety of different sign languages used worldwide and a variety of different uses of sign languages in the United States alone. ASL is a good choice due to the many resources available for learning the language and due to ASL being the primary sign language used in the Deaf community in the United States. There is also evidence that a child learning ASL will show increases in his or her English literacy skills (Strong & Prinz, 1997). Another benefit worth noting is that deaf children can become fluent in ASL, even if their parents do not have fluency in the language. As long as the hearing parents can use ASL competently, the children should be able to acquire fluency eventually.

### Importance of Technological Applications in the Deaf Community

As technology evolves and the use of the Internet becomes more widespread on a global level, the opportunities for using technology as a language teaching tool for the deaf have increased. Technology may have the potential to allow deaf children from a myriad of backgrounds to acquire appropriate language skills throughout childhood (Passig, D. & Eden, S, 2000, Nanayakkara, S., 2009, Cavender, A.C., Bigham, J.P. & Ladner, R.E., 2009). Technology can also be used as a tool to educate hearing parents of deaf children and to encourage hearing parents to learn about the Deaf community how to effectively help their child communicate and feel accepted.

With the profound changes that technology undergoes, there is a heightened need for research on technological innovations that benefit communication with the Deaf community. Instructional tools that don't utilize technology may limit a user's opportunities to learn sign language successfully. A book, for instance, may have beautiful graphics and a consistent layout but cannot incorporate features that could make it more successful for a child to use. Learning directly from a sign language interpreter is very helpful but expensive and sometimes not a good



tactic for children or parents who require more specialized types of learning. Technology, however, has the capability to use an array of features to allow a child or caregiver with various multiple intelligences (Armstrong, T., 2009) and work techniques to learn effectively. With the use of motion sensors, quality videos, animated characters, and fun and motivating tools, a deaf child could be given optimal support for learning sign language at home. Prior research has shown how technology has significantly improved learning for deaf or hard of hearing individuals through the use of virtual reality (Passig, D. & Eden, S, 2000), assistive technology (Nanayakkara, S., 2009), (Schnepp, J., & Shiver, B. 2011), and educational tools (Cavender, A.C., Bigham, J.P. & Ladner, R.E., 2009). Appropriate usage of technology could potentially lessen the barriers young children face as they are raised in the hearing world with limited resources for learning sign language successfully. Technology could also be implemented cheaply to allow families from a variety of economic backgrounds to be able to utilize that technology in an effort to teach their children sign language.

### Impacts of Technology Utilized as a Teaching Tool for ASL

If we are to address the challenges of learning ASL, we must know the existing resources. There are many resources available for individuals to learn ASL. One can do a simple Internet search to find a variety of free tutorials or enroll in a course at a local community college to learn sign language. With the resources available to learn ASL, any motivated individual with access to a college or Internet services is able to learn at least the fundamentals of sign language. With these tools readily available, many may wonder about the necessity of producing another technology for teaching parents of a deaf child to learn sign language. Others may speculate that these resources could be easily translated to be child-friendly and could be a good source for a deaf child to learn sign language.

There are many resources available, but many of these resources may contain overwhelming amounts of information, may be boring to use or provide little interaction for the user, or may not be useful for those whose learning styles may not align with these tools. There are a few large websites that have plenty of information for a user, including basic vocabulary, sentences, and tutorials for both beginners and expert level signers. As mentioned earlier, these websites are difficult for many users since the material can overwhelm a user, possibly making the user feel that there is too much to learn and just not enough time, not to mention that navigating through these resources can be a challenge in and of itself, which may impede understanding. Typically these resources lack appropriate learning aids to assist the user. Without essential feedback, learners may never successfully learn sign language, even at a basic level, solely through the use of these free resources. Lacking certain features may also cause the user to feel unmotivated and unexcited about learning sign language. Having a certain degree of motivation is essential for both the caregiver and child to adequately learn sign language. Also, some of the tools have limited functionality. For example, one website provides learners with recorded interpreters signing a given word or phrase but still lacks the capability to slow or speed up the playback. Without this playback, users who would like to see the sign more slowly, especially with more complex signs, are unable to learn the sign or misuse the sign. Furthermore, many of the teaching tools available do not account for their target audience. Many may not assume that people using these technologies could be hearing parents of deaf children who may lack the time to learn sign language or who may not be learning the most appropriate signs to help them during their child's early developmental stages. Other websites are designed primarily for hearing adults who would like to learn sign language. These sites are often not child-friendly at all. Conversely, when a teaching tool is developed for use by a generic audience, many of the

needs that hearing parents or deaf children may have will likely not be met adequately.

The following will list some of the resources currently available for parents or adults who would like to learn sign language. Some of these resources can be used by anyone for free while others must be purchased. These are websites specifically for parents to use alone or with other adults. A description of the resource and some of its strengths and weaknesses will be provided to offer a better understanding of the instructional tool.

*Table 2* Lists some of the strengths and weaknesses of instructional tools designed for parents

<b>Instructional Tool</b>	<b>Strengths</b>	<b>Weaknesses</b>
Lifeprint.com	<ul style="list-style-type: none"> <li>• Accessibility to users</li> <li>• Thorough descriptions</li> <li>• Incorporates pictures</li> <li>• Shows videos</li> </ul>	<ul style="list-style-type: none"> <li>• Difficult to read</li> <li>• The description is too lengthy</li> <li>• Hard to navigate</li> </ul>
ASLdefined.com	<ul style="list-style-type: none"> <li>• Shows videos</li> <li>• Has questionnaires to test</li> </ul>	<ul style="list-style-type: none"> <li>• Charges monthly (May not be a good resource for low income families)</li> <li>• Is not interactive</li> </ul>

**Lifeprint.com** – This website lists the first 100 signs that hearing parents may use with their deaf children. The list was compiled by selecting 100 ASL signs that are used frequently between the parent and child. The website does clarify that the parent will need to learn advanced signs at some point but that these 100 signs are to serve as a starting point. Lifeprint uses pictures to show signs with descriptions. The overall design of the website is difficult to read, and although the pictures are clear, they may not be the easiest way for parents to learn even basic ASL signs; having to read thoroughly through these lengthy descriptions of how to perform a specific sign rather than just viewing a video of the sign could end up becoming frustrating for the user.

**ASLdefined.com** – This is a website designed specifically for hearing parents of deaf

children. This is mainly an online sign language course for parents. The website mentions that children can also learn sign language with their parents. This is not a free resources and charges on a monthly basis for the courses. The website utilizes quality videos of interpreters signing along with review quizzes and matching exercises to help teach parents sign language. Parents have the ability to choose a specific word from a list and see a video recording of that sign.

### Tactics for Teaching ASL to Parents

Developing technologies to teach both children and parents sign language requires a variety of components. These components were chosen from existing research and theoretical applications. Teaching ASL to parents is integral for development of vocabulary skills with a deaf child. One of the initial steps of a language learning technology is to help parents develop at least a basic working vocabulary of ASL. Many families do not have any knowledge of ASL. Therefore, the child's exposure to ASL is nonexistent. Some exposure to ASL is more beneficial in the familial environment than no exposure. Thus, it is pertinent that a language learning system focus on integrating basic knowledge of ASL.

Studies have shown that adaptive presentation of vocabulary during training periods will have a higher likelihood of optimal learning and better retention of ASL (Henderson-Summet, Weaver, Westeyn and Starner, 2008). These results suggest the importance of a system that is adaptive to the user's responses. For instance, the content could shift in response to the changes in the user's skill level. When a system allows a user to spend more time on signs that are more difficult to learn, this will benefit the user learning ASL.

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## Creation of SignBright

SignBright was a technological prototype developed for a paper submission to the ACM CHI (Harbig, Chad, et al., 2011.) conference. I, along with Chad Harbig, Mariam Melkumyan, Lei Zhang, and Jiyoung Choi, developed the prototype. SignBright was developed specifically for a hearing parent and a deaf or hard of hearing child. The initial designs of the prototype were from studying other applications developed towards teaching children language. Unfortunately, many of these programs were not directed towards deaf or hard of hearing children learning sign languages. Two deaf students who at the time were currently in the Design program at Iowa State University were asked to give feedback on ideas for the design. My main role with the development of SignBright included the following:

1. Brainstorming and defining the use of the prototype: the topic for the CHI student competition 2011 was helping to create an application that would connect people. I had seen firsthand the issues that deaf and hard of hearing young adults had with their parents at the National Technical Institute for the Deaf in Rochester, NY. Further research into this issue showed multiple issues with deaf and hard of hearing children that were not being adequately addressed. I helped construct the idea, find literature that shed light on this issue, and helped refine the issue to relate to the topic of connection.
2. Completing the Institutional Review Board (IRB) form and other needed materials to gain IRB approval: the objective was to obtain results about initial impressions of how user friendly the SignBright prototype was. These results were collected with the intention of publishing in public venues which is why obtaining IRB approval was necessary. This process also involved creating questionnaires to record user feedback.

3. Developing verbiage and stories for the prototype: the SignBright prototype needed initial content. I performed research on words and phrases that children in early childhood would be expected to learn. These words and phrases were collected and shared with the other team members whose main role was to design the prototype. These team members filtered through the words and phrases to come up with the best designs for the initial prototype.
4. Recruiting and filming an interpreter who performed the signs: the prototype needed signs that were clear and understandable for those learning sign language. An interpreter was recruited from Iowa State University, and we used film equipment from Iowa State to record the interpreter signing the pre-approved words and phrases.
5. Programming the flash-driven prototype with Actionscript 3.0: my main role was to create a functional prototype that a user could easily navigate. I worked collaboratively with a designer to ensure that placements of avatars and other interactive objects was done appropriately.
6. Performed usability testing on SignBright: usability testing was necessary to detect any problems during the first phases of the development. I recruited users (over 90% of users were not hard of hearing or deaf), explained the purpose of SignBright, and allowed the user to explore and recording their responses.
7. Statistical analysis on usability testing: after the testing portion was finished, I analyzed the statistics and communicated that data with the other team members. Together, we all came up with an interpretation of these results and priority chart on what features needed to be fixed immediately.

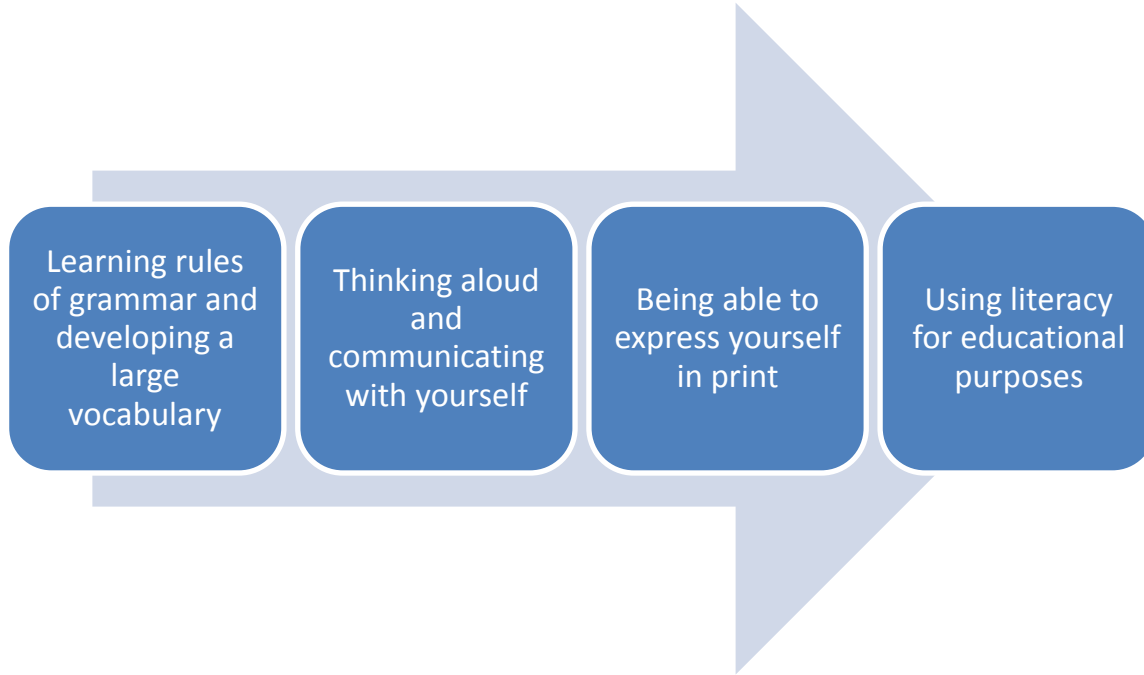
8. Paper was written for the CHI conference and other HCI conferences: I helped write much of the paper with other team members

SignBright gave some insight on the issues when designing for the deaf and hard of hearing community. The prototype had many issues that needed to be addressed. Some of these problems were similar to issues identified with other applications which helped support the idea that more research needed to be done in this area.

### Word-Learning Strategies Useful for Deaf Children

Some researchers have suggested that there are four overlapping phases in becoming literate with spoken and signed language (Quine, W., 1960, Ziegler, J.C., and Usha, G., 2006, Hiebert, E.H., and Taffy E.R. 1998). This paper will focus on the first phase of becoming literate, the phase, unfortunately that many deaf and hard-of-hearing children may not succeed at due to lack of resources. The other phases are extremely important but are out of the scope of this paper. The first phase is the development of language for face-to-face communication, such as learning a spoken language or America Sign Language (ASL), which unfortunately may not occur for many deaf children. Phase two involves employing language to think for oneself or to communicate with oneself, such as thinking aloud. The third phase, integral to literacy development, is a child being able to express himself or herself in print. The final phase is using literacy for educational means such as writing essays and involves various stages of fluency required for higher education, a standard required of many students in the United States. Figure 6 provides a brief summation of these four phases. Unfortunately, many deaf learners tend to not meet these requirements. Furthermore ASL is a language in its own right that has different syntactical and grammatical rules than spoken English. Complete and accurate translation is not possible although variations of ASL or entirely new sign systems have been designed to better

support a student in an academic climate (Liddell, S., & Johnson, R., 1989).



*Figure 6 Steps to Developing Literacy (Quine, 1960)*

How does a child become literate? More specifically, how does a deaf child achieve literacy? Children learn a significant amount of vocabulary without instruction, often through indirect means. Children have the ability to assign meanings to new words that are heard (Quine, 1960). When a child is presented a new, unrecognized word, it is unclear which part of the object or scenario the word represents. Yet children are fairly successful at these types of word-learning tasks. Why are children successful at identifying the correct object for a given word? Quine (1960) proposes that children use a variety of cognitive word-learning strategies to best understand what a new word refers to which ultimately enhances the vocabulary of that child. There is strong evidence that these word-learning strategies occur throughout childhood development and are necessary for acquiring language successfully (Regier, T., 2003 & Merriman W.E., 1999). Examining word-learning strategies specifically with deaf and hard of hearing children in mind is imperative for developing tools that help deaf and hard-of-hearing



children acquire grammar and vocabulary.

In the United States, the measurement of English literacy is connected to how well a child performs academically. How hearing children and deaf children become literate is significantly different. Hearing children become literate through the use of conversational fluency of at least one language. Afterwards, children become literate by using their conversational fluency to learn how to read. This is performed by sounding out words and receiving phonological feedback. Deaf children, however, typically do not have conversational fluency of a language, especially a verbal language. The linguistic skills of a deaf child are limited in vocabulary and grammar. Regardless, deaf children still learn to read through the same tactics that hearing children are encouraged to use. Some deaf children, particularly those with less severe hearing loss and better speech skills, may perform similar tasks to hearing children such as sounding out words verbally and reading aloud. Many deaf children will just sign or fingerspell the words or sentences out loud and are able to successfully perform these tasks without the use of any type of auditory cues (Easterbrooks, S.R., and Sharon B., 2002, Meier, R.P., 1991, Livingston, S., 1982).

It is important to understand the additional tactics a deaf child uses to achieve literacy to better incorporate these features into a language learning tool. When a designer does not account for how a deaf child achieves literacy, then they risk the tool failing to actually help the child learn advanced sign language. What techniques do children use to achieve literacy? First, the unique ability of children to rapidly learn novel words through the disambiguation effect is known as mutual exclusivity or novel mapping (Mervis, C. B., & Bertrand, J., 1994; Jaswal, V., 2010; Lederberg, A.R., Prezbindowski, A.K., and Spencer, P.E., 2000). Mutual exclusivity or novel mapping prevents a child from incorrectly calling a table a chair, or seeing a giraffe and calling it a bear. If the child knows that a giraffe is a giraffe, the child is exhibiting mutual

exclusivity or the novel mapping strategy. For example, imagine the child definitely knows what a giraffe is. When a child is shown a giraffe (familiar object) and an unfamiliar object and an adult says “that is a mouse,” the child will assume that the adult is referring to the other object that is not a giraffe. This theory is being explored due to strong evidence that mutual exclusivity or novel mapping is the primary means for both children and adults to integrate familiar and unfamiliar words into their vocabulary.

Why does the novel mapping bias occur? Different theorists have a variety of answers that are integral to other cognitive processes. One hypothesis is that the novel mapping bias occurs due to attentional bias (Merriman, W.E, 1999). The child has a tendency to attend to a new object when a new word is presented, therefore strengthening vocabulary size and associations between words and objects. Another researcher (Smith, L. B.1999) theorizes that word-learning occurs due to a combination of attention and associations. Word-learning is thereby dependent upon storage of associations between relevant linguistic characteristics and the environment. Additional theories suggest that specific cognitive development is required before these word-learning strategies can occur (Mervis, C. B., & Bertrand, J., 1994). The theory suggests that children must recognize that all categories of objects have a name, which cannot develop until the child realizes that all objects belong in a basic-level category, which may not occur until the age of two (Graham, S. A., Poulin-Dubois, D., & Baker, R. K., 1988). This theory is further extended by asserting that children must have a prerequisite linguistic knowledge of the difference between nouns and adjectives such as the difference between a green giraffe, maroon giraffe, green bear, furry dragon, and scaly dragon.

One study investigates the novel mapping strategy for the purpose of testing the universality of this specific word-learning strategy among deaf and hard of hearing preschoolers.

If theories stating that children typically acquire the novel mapping strategy with prerequisite knowledge of consistent names and differences between form classes, then deaf and hard of hearing children should be unable to develop the novel mapping strategy or, alternatively, develop the strategy at a reduced rate in comparison with the rate of their hearing peers. This idea suggests that a language learning tool must first help a child learn consistent names and the differences between form classes. This will better prepare a child for the novel mapping strategy which helps a child get through the first phase of literacy. Furthermore the study examines how children with deficient language skills, yet normal nonverbal cognitive abilities develop and use the novel mapping strategy. Friedman (1987) has shown that deaf preschoolers are two years behind their hearing peers in measures of language development but perform just as well as hearing peers on nonverbal measures.

Nineteen deaf and hard of hearing children were recruited as participants for the study. Four children had moderate to severe hearing loss, eight had severe hearing loss and seven had profound hearing loss. Sixteen of the participants had hearing parents, and three of those children had older deaf siblings. The parents reported using ASL with their deaf children. Only a few parents provided a rich linguistic environment for their child. Some parents did not sign, and the child's primary exposure to language was at school. The age at which children were exposed to language varied between three to five years of age. Some children had mild disabilities while others scored above average levels on developmental screenings. The task involved showing two different types of objects: familiar objects and novel or unfamiliar objects. The familiar objects were words that are acquired early. To ensure familiarity, teachers were asked if the student was familiar with that word. Novel words were chosen by picking out objects that a child was unlikely to know. To ensure novelty, objects were shown to five hearing preschoolers and any

object that was labeled correctly or where the child showed some familiarity with the function of the object was eliminated as a potential novel object to show a child. Novel words were invented in ASL which were slight variations of existing words. For example, “dax” was a word created in ASL to assign to an object a child may not recognize.

The study consisted of two parts. The first part of the experiment consisted of a familiarization, novel mapping and rapid word-learning task. For all the tasks, preschoolers were given nonspecific feedback about their responses. Nonspecific feedback includes the experimenters saying “Thank you” after each response and not telling the preschooler if his or her response was correct or incorrect. The familiarization task included presenting four familiar objects to preschoolers. The experimenters asked the preschoolers questions such as “cup, cup, where is cup?” in ASL, and the preschoolers had to correctly choose the object. For this task, almost all the preschoolers were able to do this task successfully, and the one participant who had trouble was not included in the rest of the study. The novel mapping task involved presenting the preschoolers with three familiar objects and one novel object. A child would be asked “dax, dax, where is dax?” and the experimenter would observe if the child chose the novel object. Novel distracters were also used in the task to ensure that the child was actually learning that dax applied to that novel object and not to any novel object. The rapid word-learning tasks were exactly like the novel mapping task, but all objects were labeled by the experimenter. For example, four objects were presented and an experimenter would say "apple, apple, look apple; cookie, cookie, look cookie; lep, lep, look lep; mommy, mommy, look mommy.” The results of these tasks showed that children do use the novel mapping strategy. Some of these children were capable of learning words quickly with the novel mapping task. Others required adults to reference all the words directly through the rapid word-learning task, while others were unable to

learn through either context.

The second part of the study involved the seven children who were unable to learn through either context. The experimenters retested these children over an eighteen month period. Children were retested until they demonstrated the novel mapping strategy. Due to some preschoolers changing schools, children were retested at different times, but the average time from the initial test to the second test was seven months while the average time was six months from the second test to the third test. The results of this portion of the study showed that children who take longer to develop word-learning strategies learn vocabulary more slowly. The results of the study suggested that children need a lexicon consisting of at least two hundred words before they can develop word-learning strategies. This research supports the premise that word-learning strategies may develop in early childhood. The results of this research also demonstrate that word-learning strategies may be universal and can be used with Deaf and hard-of-hearing children. Deaf and hard-of-hearing children may learn these words quickly in different contexts, but with vocabulary development and different contextual cues, these children can still develop word-learning strategies. The overall results of the study showed that all the children eventually developed the novel mapping strategy regardless of their backgrounds, ages and familial environments. The novel mapping strategy is an important consideration when designing a tool for a deaf child. Ensuring the child has a lexicon of at least two hundred words is imperative before one introduces word-learning strategies. The novel mapping bias could even be replicated in a system to see how quickly children can learn new words.

Another study (Stelmachowicz, P.G., Pittman, A.L., Hoover, B.M., & Lewis, D.E. 2004) sheds additional light on word-learning with the deaf population. According to research, word form does not influence how likely a child will be to learn a word. Regardless of whether a word

is a noun or a verb, the child could still apply word-learning strategies successfully. However, it is possible for children to be more able to learn nouns (Rice, 1994) or verbs (Horohov & Oetting). An instructional tool (Horohov & Oetting) may have a verb advantage if scenes have a high interest value or visible actions by characters. A tool should encourage high verb performance as well. It is important to consider reducing the ambiguity of verbs when introducing new words to a deaf child. This was achieved in research by (Stelmachowicz et al, 2004), by ensuring that context cues were available for both nouns and verbs. An example for nouns could be, “she likes the *bath tub*,” while an example for verbs could be, “I want the water *to boil*.” Note that the italicized words would be unrecognizable to the child. The context would be clear to the child, but the emphasis would be placed on the italicized word. A tool should ensure that children have both an advantage to learn nouns and verbs.

The paper has just summarized phase one, early literacy development. Phase two involves the child being able to communicate with themselves. Language is now being used as a tool for thinking out loud. The child must learn to apply the language in an egocentric manner, allowing the child to actually think in the language that he or she is signing in.

This research dealing with the cognitive processes of linguistic development has been a crucial motivation for designing language learning applications for deaf and hard of hearing children. From the literature review conducted, it's evident that word-learning strategies are critical for a child's development and to enhance their lexical processing skills. Word-learning strategies should not be ignored when designing a system for the deaf and hard of hearing. From this information it's clear that it's important that the system helps to build vocabulary. Feeding children additional words to learn will increase the probability that these children will independently use word-learning strategies (Stelmachowicz et al, 2004, Mervis, C. B., &

Bertrand, J., 1994). The novel mapping skill should also be implemented somewhere in the design once it has been established that the child has a sufficiently large lexicon and understands some grammatical skills. It is integral to a child's development to be able to independently do novel mapping as that skill will only enhance his or her literacy development. Lexical processing and other similar cognitive psychological ideas have been extremely helpful in designing a language learning system for deaf and hard of hearing children. This will continually be referenced and applied as development of this framework continues.

### Variables Influencing Achievement

Understanding the variables each individual faces when learning is important to consider when understanding which target audience to design for. Predictors of success in both academic and non-academic communication are integral for understanding the specific limitations that could potentially obstruct each individual (Convertino, C.M., 2009). The section describes prior research focusing on the more immediate considerations to be addressed when teaching deaf children. These results are primarily for young deaf and hard of hearing children. These results may change when a child enters secondary school or college. Due to the scope of the paper, I have primarily focused on achievement variables with children in primary school.

Anyway, let us first examine how these variables are adjusted with Db-loss. In terms of audiology, there is conflicting data about performance with hearing loss. Some studies (Blair, J.C., 1985, Jensema, C., 1975) show that the greater the hearing loss, the poorer the achievement while another (Davis, Julia M., et al., 1989) shows that the level of hearing loss has little impact on achievement. Gender differences among deaf and hearing students are similar (Mitchell, R.E., and Michael A.K., 2011, Convertino, C.M., et al., 2009). Males perform better at mathematics while women perform better at reading, but again this data can vary (Antia, S.D., et al., 2009,

Convertino, C.M., et al., 2009). Deaf children who are born to deaf parents typically are higher achieving than deaf children born to hearing parents (Antia, S.D., et al., 2009, Convertino, C.M., et al., 2009, Mitchell, R.E., and Michael A.K., 2011). Studies (Convertino, C.M., et al., 2009, Mitchell, R.E., and Michael A.K., 2011) have suggested multiple reasons for the discrepancy. The first reason is the higher self-esteem of deaf children born to deaf parents. Deaf children born to hearing parents, however, have potential negative obstructions. This can include the following:

- Mislabeled cognitive disabilities that may or may not be present
- An environment that may or may not be accepting
- And a hearing parent's lack of linguistic skills necessary for the development of his or her child's language abilities.

In terms of ethnicity, studies have shown (Mitchell, R.E., and Michael A.K., 2011, Convertino, C.M., et al., 2009) that nonwhites perform slightly worse than whites. This is consistent with achievement rates among hearing communities. Relying on this data about ethnicity alone would leave an incomplete picture since other factors such as SES seem to be more relevant. Deaf children coming from families with a higher SES tend to perform much better with communication and attain greater academic achievements than children coming from a lower SES (Powers, S., 2003). The research of Convertino (2009) also showed that deaf and hard of hearing students who have been mainstreamed do not have any significant differences in study patterns compared to their hearing peers.

To further understand the problem, let's look at the individual limitations placed upon a deaf learner. A deaf learner will typically have inadequate language skills and will have reduced input due to hearing loss. There are inadequate teaching methods for deaf learners. Teachers



focus on sentence structure over other aspects of language use, further limiting the possibility of achieving literacy.

### Current Instructional Tools for Children

Various technologies have been employed to augment educational or language learning tools for deaf and hard-of-hearing children (Adamo-Villani, N., and Wilbur, R., 2009; Adamo-Villani, N., and Wilbur, R., 2007; Adamo-Villani, N., Doublestein, J., and Martin, Z., 2007). Though many are limited in capability, not effective, or limit their audience. However, technological solutions that adequately address both the social and linguistic needs of deaf children are nearly non-existent. An appropriate solution is required to connect deaf children and hearing parents, promote mutual understanding, provide deaf children with an effective means of expression, and foster cognitive development and language competency.

Over a hundred instructional tools are available for children to develop ASL skills at home or at school. Developing software solutions for deaf and hard of hearing children is important due to the proliferation of technology and its frequent use by children. Software technologies have more engaging options to help children learn ASL than non-technological items such as books. These phenomena may be due to the benefit of software applications being versatile and having capabilities such as gesture recognition, feedback, videos and interactivity. Secondly, children express enjoyment and additional motivation for learning when software is used as one of the primary mediums (Ardito, C. et al., 2004). The following lists some instructional tools aimed at helping deaf and hard-of-hearing children learn ASL successfully. These tools were chosen due to their popularity and use in deaf and hard of hearing populations. Table 3 provides a brief description of the tool and some of its strengths and weaknesses.

Table 3 Description of instructional tools designed specifically for children

Tool	Strengths	Weaknesses
CopyCat	<ul style="list-style-type: none"> <li>• Gesture recognition tool for feedback</li> <li>• Fun and engaging</li> </ul>	<ul style="list-style-type: none"> <li>• Inaccurate feedback tool</li> <li>• Poor graphical interface</li> <li>• Expensive and inaccessible to many families</li> </ul>
SignTutor	<ul style="list-style-type: none"> <li>• Provides feedback</li> <li>• Allows users to watch themselves sign</li> <li>• Shows videos of someone signing</li> </ul>	<ul style="list-style-type: none"> <li>• Does not provide automated feedback to the user.</li> <li>• Good for older children but not young children.</li> <li>• Does not include advanced signs.</li> </ul>
SMILE	<ul style="list-style-type: none"> <li>• Fun</li> <li>• Motivating</li> <li>• Good for children of all ages</li> <li>• Has a secondary effect of motivating users to learn math and science</li> </ul>	<ul style="list-style-type: none"> <li>• There is no feedback given</li> <li>• Very expensive and inaccessible to most families.</li> <li>• Focuses on multiple disciplines which may deter a user from learning sign language.</li> <li>• Does not include advanced signs.</li> </ul>
PlayTime Series Book	<ul style="list-style-type: none"> <li>• Beautiful illustrations</li> <li>• Has a target audience specifically for children</li> </ul>	<ul style="list-style-type: none"> <li>• Does not include advanced signs.</li> <li>• Not motivating for older children.</li> <li>• Not interactive</li> <li>• There is no feedback</li> <li>• Does not provide another method for a child to learn a sign, other than viewing a picture of a sign.</li> </ul>
Lifepint.com	<ul style="list-style-type: none"> <li>• Incorporates videos, descriptions and pictures for learning a sign.</li> </ul>	<ul style="list-style-type: none"> <li>• Cluttered visual layout</li> <li>• No feedback to user</li> <li>• No interactivity</li> </ul>

The list provides a description of the tools and their strengths and weaknesses.

**CopyCat** (Zafrulla, Z., et al., 2010) Website: <http://www.cats.gatech.edu/content/copycat>

– This is a series of educational adventure games designed for deaf children with the goal of helping children improve their language skills. The child communicates with a hero or heroine, such as a cat, and gives the hero or heroine instructions on what to do during various parts of the game. The system is presented via a web browser that uses Flash and a web cam. This tool is unique in that it uses gesture recognition technology, and much of the vocabulary is presented to the child through the web browser. Children wear gloves to interact with the system. The system has been shown to be educationally beneficial to the deaf learner. However, CopyCat is still in the process of making improvements with the gesture recognition portion of the tool. Furthermore, there are limitations with how complex the language can become. In other words, children may be able to use simple vocabulary, but advanced grammar and increased fluency may not be easily supported with the tool.

The main strength of this tool is that it provides feedback to the user. Gesture recognition technology allows the child to actually practice signing and receive feedback on where he or she needs improvement. Furthermore, the child is presented material in a fun and engaging manner which helps minimize the possibility of a child losing motivation or becoming bored.

A clear weakness of the research project is that it is still undergoing development. Although the gesture recognition technology is a great asset, the child may eventually outgrow the system as he or she learns more signs. Furthermore, much of the graphical interface resembles those built over a decade ago. Lastly, the system may not be accessible for much of the deaf community. Children coming from families with a lower SES may never have the opportunity to be introduced to this technology.

**SignTutor** (Aran, O., et al., 2009) – This interactive tool allows deaf learners to learn and improve their sign language skills by watching themselves sign. The system uses a screen where

the application plays. It incorporates a web cam that focuses on the upper body for hand and head movement. This process validates their own performance. The user scrolls through a list of words. After clicking on a word, the user can see the sign and using a camera can replicate the sign that he or she sees. Feedback is given through this recorded video, animations, and text messages. The study shows that users found this system to be a positive experience, especially the system's capability to show them themselves as they were signing.

A benefit of using SignTutor is it allows the user to view how he or she is signing. Although the system does not provide direct feedback on a user's progress, it does allow a user to at least see their signs and compare to their signs to the video feeds that he or she is viewing. Unfortunately, the system seems more aimed for older users rather than young children and may not have the motivational characteristics that a system designed to teach sign language would require. The software will need to contain more advanced signs and grammars to continue to challenge its learners.

**SMILE** (Adamo-Villani, N., et al., 2007) – SMILE is immersive virtual reality room, and can be displayed in stationary virtual reality projection system. Students use gloves or a wand equipped with a wrist tracker for interaction with the system. The goal of this game is to help every member living in the city of Smileville to smile again. Users are able to perform a variety of functions such as exploration of Smileville, manipulation of objects in that environment, and interaction with the characters. SMILE is designed for users between the ages of five and ten who are deaf and hard-of-hearing. This game uses a combination of virtual reality and bilingual interfaces to bolster motivation for deaf and hard of hearing students in math and science. The game helps children learn ASL terminology and varying mathematical and scientific concepts. For a child to progress in the game and to meet the ultimate objective, the child must continually

be learning ASL and some STEM concepts. SMILE also demonstrated that children enjoy using virtual reality as an educational tool.

One main benefit of SMILE is that the game is fun for children. There is a clear goal outlined for the child, and the child is motivated to try and meet that goal. The delivery of the tool is also entertaining. Virtual reality helps makes the experience more immersive and engaging for children. SMILE also helps a child develop other skills in addition to linguistic aptitude. The application helps motivate children to not only succeed at signing, but also to find interest in the areas of math and science.

One disadvantage of SMILE is that the system is not accessible to most children and parents. The system is expensive and is not available in most locations. Most families would not have access to a virtual reality system or interactive gloves. Another disadvantage is the focus on multiple disciplines. A better tool would be primarily focused on learning sign language and would focus its efforts on that. The user would eventually hit a plateau on how much he or she could learn from this system. Lastly, the system does not provide feedback of any kind. The user is not given the necessary resources to understand when he or she is making mistakes.

**Sign Language: My First 100 Words** (Editors at Scholastic, 2008) – These are a series of illustrative books available for young children that are ages one and older. The goal of these books is to introduce various signs for common activities such as playing music, participating sports, or going to the park. The book uses accurate illustrations of signs to help someone of all ages learn basic signs.

The books have a clear audience: children. Therefore, one of the strengths of these books is that they were specifically developed and designed for children. The pictures are meant to be rich and very aesthetically pleasing for a young child. The focus is also on basic signs, which

include signs used frequently around the home. These signs are meant to help a child with more advanced signs and grammar.

However, a book may not be the best medium for older children to learn. The book can be used with children of all ages, but children past early childhood may grow bored with the book. There may be a lack of motivation for an older child to want to consistently use the book. Some children and parents may not learn successfully from just this book. The pictures in the book are clear, but some users will need additional feedback. The book does not seem to address that. Lastly, the book is only helpful up to a certain point. The book is not adaptive since the books provide little assistance with more advanced signs.

**LifePrint** <http://lifeprint.com/> – This is a very comprehensive website mainly focused on teaching adults sign language at home. LifePrint uses a combination of videos, memory aids, and written text to compile lessons designed to teach adults. It is unclear who the main target audience of LifePrint is. The website uses written English to provide instructions which may be too advanced for a young child to understand. It is a fair assumption that the website may be primarily designed for an adult. If a child needed to use the website, he or she would be required to have the assistance of a parent to understand the website.

One strength of the website is the amount of material available to a user. LifePrint contains a large database of videos, tutorials, and written instructions to help a user trying to understand sign language. This is excellent for users who require additional assistance when learning sign language or for users who learn best using multiple mediums.

Unfortunately, the website contains too much information which is poorly presented. A first time user may be confused about where to begin. For example, the website provides little guidance on whether a beginning parent should be learning numbers, finger spelling, or other

signs first. The user would most likely have to purchase another tool to provide guidance on how he or she should begin learning sign language. The navigation can also be confusing for a user. It is extremely easy to miss pieces of information, and it is not clear how a user could learn from this website every day, especially since there is little support for bookmarking where a user has left off.

For the study, three different types of instructional tools were chosen: book, website and software application. Each has clear benefits and obstacles.

1. The book, for instance, is mobile and very physical. It can be used in almost any location easily such as a car, in bed, at work, etc. A book is a tool that many groups are familiar with and already know how to utilize. However, the book may not be as versatile and interactive as other venues for learning. The book may not convey signs as easily as a video from a website or software application.
2. A website can be accessed anywhere as long as there is appropriate network connectivity and a computer available. The website could be a cheap alternative for low income families who may not be able to invest in a series of books or pay for learning applications. However, the website could be limited in terms of affordances for collaborative experience and may not be an easy tool to develop connection between both a parent and child.
3. A software application has the possibility to be interactive and engaging for both a child and parent. An application could be used on a tablet, mobile device, and computer. In general, software applications may be considered to be expensive which may deter families from lower incomes to not want to purchase the application. Yet it is still possible to make an inexpensive or even free application for a parent to use.

## CHAPTER 3

### Methodology

Due to the research question focusing on how users evaluate three different instructional tools, much of the methodology is qualitative. Likert questions have been added to the evaluation questionnaire to add some element of quantitative measurement, but the rest of the questionnaire is qualitative. Three quantitative questionnaires are included in this study for the purposes of measuring a history of stress, poor interpersonal relationships and negative cognitive appraisals.

#### Participants

Participants were 8 adults recruited via word of mouth from known networks of Deaf communities. Participants did not receive any compensation for their participation in the study. Four participants were hearing parents and consisted of 2 females and 2 males between the ages of 18-65 (Median age = 42.5 years). All participants from the parental group were Caucasian. Participants were married and had children between the ages of 3-15 (Median age = 10.1). Therefore two couples participated, for a total of four parent participants. Participants had at least one child who had been classified as deaf or hard of hearing. This group was important to receive a perspective from a parent who had experience raising a deaf or hard of hearing child. However, please note that these were all approximations of the type of participants needed. Ideally the participant would have had a deaf child who was between 6 months to 1 year old, but due to difficulties with recruitment, participants with a deaf or hard of hearing child qualified for the study.

Four participants were hard of hearing or deaf and were not parents. They were between the ages of 18-25 (Median age = 21.1 years). Two of the participants were Caucasian, 1 participant was Asian-American and 1 was of Latino/Hispanic descent. The participants were



young adults and due to time lines and IRB challenges, this group was chosen over actual deaf and hard of hearing children. Deaf and hard of hearing young adults' feedback was useful since they had experienced challenges learning sign language, understanding the language now, and had provided feedback on what works, and had provided input on whether they felt each tool would have helped them connect with their parents. All participants signed a voluntary, written informed consent form that outlined the nature of the study and the types of questions that would be asked. All participant responses were anonymous, and each participant was given the option to skip questions or stop participating in the study at any time, without risk or any type of penalty. All participants who were hard of hearing or deaf completed self-report measures of childhood abuse and neglect (the Childhood Trauma Questionnaire; CTQ), the quality of attachment and interpersonal functioning with parents and peers (Inventory of Parent and Peer Attachment; IPPA), a measure of perceived stress (Perceived Stress Scale; (PSS). Hearing parents were only asked to complete the PSS. These instruments were chosen due to a high incidence of negative interpersonal relationships with parents and peers among the deaf and hard of hearing populace. Furthermore, deaf and hard of hearing children have reported higher levels of stress than peers. These measures were administered to see if there would be an impact on stress and interpersonal relationships with how the tool is perceived.

## Measures

*Inventory of Parent and Peer Attachment (IPPA)*. (Armsden and Greenberg, 1987). The IPPA consists of 75 items that assess an individual's perceptions of their relationships with their parents and peers. The dimensions that are assessed by the IPPA are degree of mutual trust, quality of communication, and the extent of anger and alienation. The IPPA responses are based on a 5-point Likert Scale that consists of 25 items each for the mother, father, and peers, totaling

75 items for the entire questionnaire..

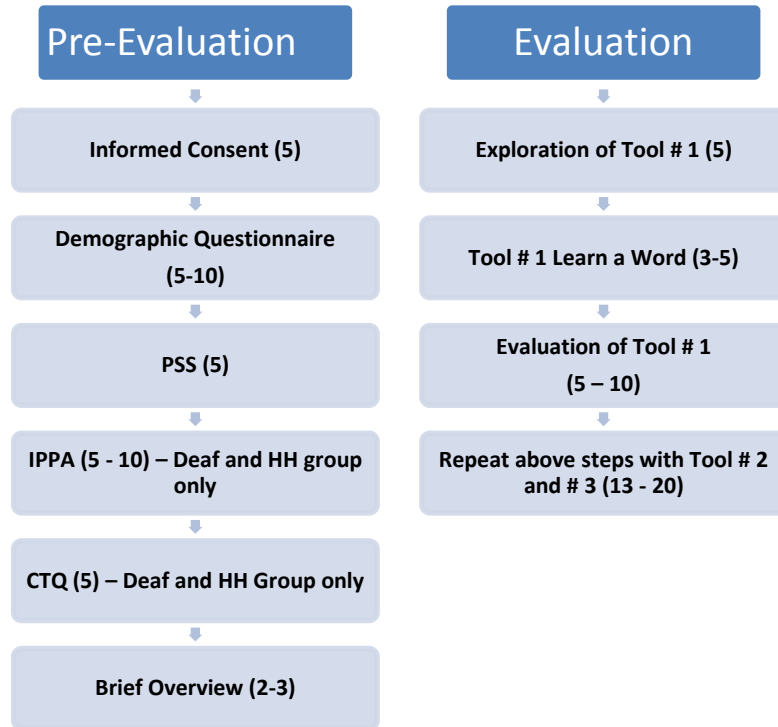
*Childhood Trauma Questionnaire (CTQ)*. (Bernstein and Fink, 1998) The 28-item version of the CTQ is a self-report inventory that assesses 5 types of childhood abuse: emotional, physical, sexual, emotional neglect, and physical neglect. The CTQ responses are based on a 5-point Likert scale with responses that range from “Never True” to “Very Often True.” There are established scores for none, mild, moderate and severe types of abuse.

*Perceived Stress Scale (PSS)*. (Cohen, Kamarck and Mermelstein, 1983) The 10-item questionnaire is a measure of the degree in which situations of daily life are appraised as stressful. The questions ask about feelings and thoughts over the past month. PSS responses are based on a 5-point Likert scale with responses that range from “Never” to “Very Often.”

## Procedures

The study portion was done in the participant’s home environment. In one situation, the participant completed the study at a quiet coffee shop due to personal reasons. Before beginning the study, participants were first given an informed consent form. At this time, participants were asked if they felt comfortable communicating on the computer via a Microsoft Word document. All participants reported feeling comfortable communicating by typing on a Microsoft Word document. However, all of the hearing parents requested that it was easier to be spoken to verbally. Therefore the primary mode of communication with the hearing parents was done verbally, both ways. Two participants were hard of hearing but preferred verbal communication. One participant preferred lip reading as the primary mode of communication. The last participant preferred communicating by a combination of lip reading and typing on the computer. The goal of asking participants about their preferences was to ensure the participants felt comfortable with communicating and that the conversation is fluid. Figure 7 gives a brief snapshot of the

experimental procedure. More thorough discussion about the procedure is provided below.



*Figure 7 The following is a summary of the experimental procedures. The number in the parentheses represents the length of time in minutes that it took for the participant to complete each portion.*

After participants signed the informed consent, they were asked to complete a demographic form (see Appendix A4). The demographic form had questions relating to socioeconomic status, gender, levels of hearing impairment, and questions related to whether the participant had been mainstreamed in school.

After completing the demographic form, the participant was asked to complete the Perceived Stress Scale (PSS) (see Appendix A1), Inventory of Parent and Peer Attachment (IPPA) (see Appendix A2) and the Childhood Trauma Questionnaire (CTQ) (see Appendix A3). Participants who were parents were asked to complete only the PSS questionnaire. All questionnaires were completed on a laptop provided by the researcher. Please note that participants were given space to freely type their responses to the questionnaires to help prevent

participant anxiety about their responses. However, the researcher was in the same room to observe any responses and provide assistance if necessary. After completing the questionnaires, users were given another description about the purpose of the study. Users were reminded that both the parent and the child would need to use the tools to learn sign language. This reminder was necessary so that participants could judge the tool based on how caregivers and children would interact with the tool together.

After hearing the detailed explanation about the experiment, participants were shown the following three language-learning tools in counterbalanced order: LifePrint: 100 First Signs (Website), SignBright Prototype (Software Application) and Sign Language: My First 100 Words (Book). Figure 8 provides a glimpse of what each of these tools looks like. All participants focused on learning basic signs appropriate for early childhood. Both the website and software application were viewed through a computer provided by the research. The participant was given five minutes to look freely through the instructional tool. Each participant was given explicit instructions to navigate through the tool as if he or she were interested in learning sign language. After the five minute span for exploration was over, the participant was given a specific task. Each task involved learning a basic word. For instance, a participant might be instructed to learn how to sign “apple.” The participant was given a different word to learn for each task.



Figure 8 Three applications were evaluated for the study, the software prototype: SignBright, the website: LifePrint and the book: Sign Language: My First 100 words

The user is shown the first tool and when the task has ended, is given a survey. Afterwards, the user is shown the second tool, and is asked to complete the survey. Finally, the user is shown the third tool, and will complete the survey. After the user was finished with each tool, he or she was given a follow-up questionnaire to complete. The follow-up questionnaire asked questions related to how exciting and motivational the tool is, its weaknesses and strengths, whether or not the participant could connect with his or her parent/child using the tool, the tool's navigation, as well as its content and overall design (see Appendix A5). All parents specifically requested to complete the questionnaire verbally, and felt that was an easier way to communicate about the medium. Deaf and hard of hearing participants completed the questionnaire electronically, which involved the user typing responses on the computer. After all the tasks and surveys were completed, users were asked which tool he or she personally

preferred and were asked why or why not. All responses were recorded by the researcher.



*Figure 9 Attributes to Constructs for Questionnaires. The first column represents the components for consideration in the Introduction. The second column addresses how they were referenced in the questionnaire.*

As mentioned in the Introduction, the various components to consider when designing an instructional tool include fantasy, presentation, personalization, user activity, feedback, storytelling, adaptability, age and challenge. However, these terms may have different meanings to the user. For instance, different users may have varying definitions of what fantasy means. A method to ensure the user had a similar understanding to the items in the questionnaire was needed. To make these terms more understandable, alternative words that have similar meanings were used to assess and measure each component in the different learning tools (see Figure 9). Please note that adaptability, age and challenge could not be measured for this study. Adaptability and challenge would require long term usage of each of the tools which is out of scope for the study. This study was focusing on early childhood age and did not have approval

for doing this study with children of different age groups. Therefore focusing on the age component would be irrelevant.

Questions about excitement, motivation and entertainment were asked to represent how fun each tool was and its individual fantasy elements. Open-ended questions were given to allow the user to extrapolate on this. The questions about the design and content are related to the presentation component. The questionnaire asked about communication and connection which directly relate to the aspects of storytelling that were explored. Lastly, questions about design, content, navigation and usability were asked to better measure the components of personalization, presentation, user activity and feedback.

## CHAPTER 4

### Results

#### Analysis of questionnaires

A series of analyses were completed in order to test whether there was an association between individuals who reported a history of childhood abuse and neglect, poor interpersonal relationships and higher perceived stress with the types of features and feedback given from tools. Due to the small sample size it is not possible to draw statistically significant conclusions from results on the questionnaires. However, one participant reported significantly more negative cognitive appraisals of themselves, others and their futures. This participant reported problematic interpersonal functioning with their father and mother but not peers. The other three deaf and hard of hearing participants' scores on the questionnaires showed a high appraisal of themselves, higher attachment with parents and peers, and stress was not high.

Parents of deaf and hard of hearing children all scored low on the stress scale. However, two of the participants reported that their responses are not typical for a given year. The study was completed during the summer and two of the participants were teachers. These participants mentioned that their stress levels are much higher annually but over the past month, stress levels were not as high. The participants did not report high stress, low attachment with parents and peers or a low cognitive appraisal. However, if they had, this may have influenced the design of tools. For instance, a low cognitive appraisal may have provided more guidance on the motivating characteristics of using a language learning tool. For instance, it may be possible that a user with low cognitive appraisal may need additional feedback on their performance when doing signs or they may like a tool that shows deafness positively and helps them feel more positively about their deafness. This is an element that would need to be studied in future



research. A participant, who reported a higher stress level, may provide additional insight on how concise and clear information should be presented. The participant may also provide insight on how much information should be displayed per session. It is possible that users who report having a poorer relationship with parents and peers may have additional insight on how the tool can help a child better connect and communicate with a caregiver. These are all necessary components that should be identified and discussed in future research.

## Qualitative Analysis

### Book

#### *Excitement, Motivation, Entertainment*

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##### *Parents*

One of four respondents reported that the book was not exciting to use at all. Three of four users reported that they were somewhat excited about using the book. One of four respondents reported that the book was a little motivating to use. Three of the users reported that they were somewhat motivated to use the book. Two users reported that the book is somewhat entertaining while the other two users reported that the book is a little entertaining. Participant responses mentioned that the book might offer short-term motivation and excitement but would not be fun to use after a few times. In other words, the book seemed to be a good supplemental learning tool, but not good to use as a long term strategy with learning sign language. One male respondent mentioned possibly using the book simply to help his or her child but would not enjoy using it himself. My sense was that as a whole, participants did not seem eager to use the book as their main learning tool.

### ***Deaf and Hard of Hearing***

When I brought up the topic with deaf and hard of hearing participants, the response to the book was more positive than the hearing parent's group response. Three of four respondents said using the book was somewhat exciting, while one of the respondents said the book was exciting. Three respondents said the book was somewhat entertaining to use while one said the book was entertaining to use. Three respondents said the book was somewhat motivational and one said the book was motivational. Three of the responses mentioned that the book was very fun and that the participants would have loved to use the book as a child. However, three respondents mentioned that the book would probably not retain the interest of many children and would need to be more interactive. Overall, from my observations, all of the users in the deaf and hard of hearing group really enjoyed using the book, and were engaged with learning the signs.

### ***Design***

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Users were given some guidance about how to define design. Participants were instructed that design may involve how aesthetically pleasing the images are, the clarity and conciseness of the visual structure of components, and how well sketches or videos helped the user achieve their goal of learning sign language. Open-ended questions provided better clarity on the user's opinions about the design components. Figure 10 shows a picture of one of the pages a participant may have seen when observing the book.



Figure 10 A picture of the book, *Sign Language: My First 100 Words*. This picture displays some basic signs a child might learn that is related to the classroom.

### **Parents**

Two of the respondents rated the design as 4/5 and the other two rated it as a 5/5. None of the respondents had any negative comments about the design. Positive comments about the design include that the book is fun to look at and the designs are very enjoyable for children. Upon observation, one respondent was really happy to see the diversity of the children and adults in the photos.

### **Deaf and Hard of Hearing**

All of the respondents rated the design as 5/5. None of the respondents had any negative feedback about the design. Positive comments included that the signs were realistic and the book is fun to look at.

## ***Content***

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### ***Parents***

One of the respondents rated the content as 3/5. Three respondents rated the content as a 4/5. Two of the participants clarified that the content was good but did not include all the information that they wanted. One of the participants also reported that the content was not complex.

### ***Deaf and Hard of Hearing***

Two of the respondents rated the content as 4/5 while the other two rated the content as 5/5. Three respondents verbally mentioned that they enjoyed the content. Two respondents mentioned that the content only teaches basic signs and could use improvement.

## ***Navigation***

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To measure navigation a question asked a “yes” or “no” question about whether the navigation was easy to use. A secondary question with a Likert scale was added to better measure how navigable each medium was perceived. Respondents were observed to see if there were any visible or verbal frustrations about the navigations.

### ***Parents***

All users from the parental group answered that the navigation was easy to use. Three of the four respondents ranked the navigation for the book as a 4/5 or easy to use. One of the respondents rated it as a 3/5. When asked why they chose to rank the navigation, three respondents reported that the book used familiar concepts such as an index, table of contents and various references. Three parents expressed excitement about the pictures of signs at the back of the book. Respondents did have negative feedback about the time between navigating to an index

or table of contents. Two respondents felt that finding specific signs could waste time and even be frustrating if multiple things needed to be referenced.

### ***Deaf and Hard of Hearing***

All users answered that the navigation was easy to use. One of the respondents rated the navigation as 4/5 while three of the other users rated the navigation as 5/5. Three users enjoyed having the option to use a table of contents and index. Two users commented that the navigation might be difficult for a child to understand.

### ***Usability***

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#### ***Parents***

One of the respondents rated the usability as a 3/5. Two respondents rated the usability as a 4/5 while the other one respondent rated the usability as a 5/5. Participants reported that the book is familiar and easy to use. One negative response mentioned that constant navigating to the index and table of contents made the book difficult to use. Another negative response mentioned confusion about how to use the sign map at the back of the book.

### ***Deaf and Hard of Hearing***

Two of the respondents rated the usability of the book as 4/5 while the other two rated the book as 5/5. There was no negative feedback reported about the usability. Three of the users expressed verbally that the book was simple to use.

### ***Connection and Communication***

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#### ***Parents***

Individually, the data shows that two of the respondents report the book can help them

connect and communicate with their child. Respondents who reported the book could help them connect reported that being able to share a book with a child is natural and fun. The parents who felt the book could not help them connect with their child gave reasons such as their child being older. These parents reported that the book is excellent for young children but not a child past the age of five. Two of the users commented that the child could easily sign with the parent while immediately referring to the book. This could be done anywhere and at any time such as the park, bedtime and so on. The other two respondents who felt the book would not improve communication cited reasons such as limited gestures and confusion about how to follow the pictures.

### ***Deaf and Hard of Hearing***

All of the users reported that the book could help them communicate and connect with their caregiver. All users commented that the book is a great tool for interacting with parents. However, three respondents mentioned that the book is ideal for younger children.

### **Website**

### ***Excitement, Motivation, Entertainment***

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#### ***Parents***

Three respondents reported that they were somewhat excited about learning sign language when using the website. One respondent reported that they were a little excited about learning sign language with the website. Three of the users said the website was a little motivating and the one said it was not motivating at all. All of the respondents said the website was a little entertaining. Three respondents reported that the website was overwhelming. There was a lot of information to learn, and made them feel like they could not learn all that

information. One respondent reported that the website was so displeasing to look at that he or she would not want to learn sign language from that medium. Another respondent felt the website was too confusing.

### ***Deaf and Hard of Hearing***

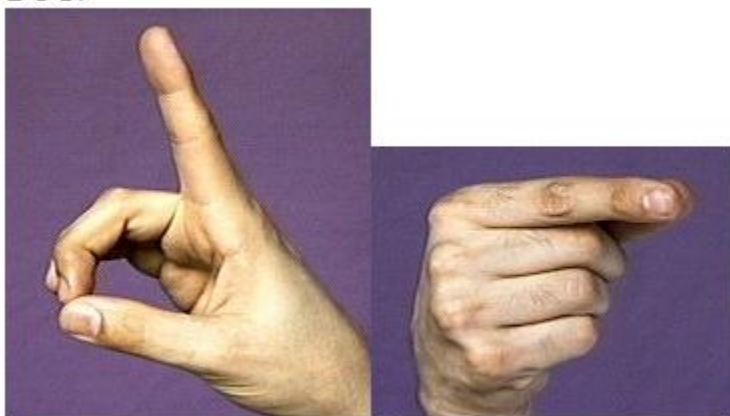
Three respondents reported that they were a little excited about learning sign language and one participant mentioned that they were somewhat excited about learning sign language with the website. All of the participants said the website was a little motivating. Two of the respondents said the website was somewhat entertaining, one said the website was a little entertaining and one said the website was not entertaining at all. All respondents made some mention of the website being very confusing, which led to them feeling more disinterested. One participant mentioned that there was too much text to make sense of.

### ***Design***

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Respondents were given instructions to rank the design of the website. Figure 11 shows a sample of what the signs look like for the word dog on the website.

DOG:



*Figure 11 This is how the signs are displayed for the word dog on the website, Lifeprint.com (http://lifeprint.com/asl101/pages-layout/permission.htm) © 2004, www.Lifeprint.com. Obtained*

*permission.*

### ***Parents***

All of the respondents rated the design as a 3/5. Two of the participants reported that the design was boring and simplistic. Upon observation, one respondent humorously mentioned that there was no design of the website.

### ***Deaf and Hard of Hearing***

Three of the respondents rated the design as a 2/5 while one of the respondents rated the design as 3/5. Two of the respondents said the website looked terrible, was really ugly and would not want to reuse a site that looked like that.

### ***Design***

---

Respondents were asked to report how they ranked the content of the website. Figure 12 shows a sample of how content is displayed for a single word on the website. In this sample, the sign day is shown and there is adjoining text.



The sign for "day" is made by holding your non-dominant arm (the left arm for most people) in front of you, palm down, pointing right. Your left hand can be in either a "flat handshape" or an "index finger handshape." Your dominant hand (the right hand for most people) can be either an "index finger" or a "flat hand." (I don't recommend a "D" hand, that is Signed English.) Rest your right elbow on the back of the left hand. Your right arm should point up. Move your right arm across your body, the hand tracing an arc while keeping the right elbow on or very near the back of the left hand. Note: advanced signers often do very abbreviated versions of signs. For example, they may do the sign for day with the tips of the fingers of left hand touching the midpoint of the right forearm instead of resting the right elbow on the back of the left hand. Also, you might see a different palm orientation on the dominant hand.



*Figure 12 This is a snippet of some of the text for the sign day on the website, Lifeprint.com (<http://lifeprint.com/asl101/pages-signs/d/day.htm>) © 2004, www.Lifeprint.com. Obtained permission.*

### **Parents**

Two of the participants rated the content as 4/5 while the other two participants rated the content as 5/5. All participants commented that the website was thorough and contained tons of information. The only negative response is that the content was a bit difficult to read and understand.

### **Deaf and Hard of Hearing**

Three of the respondents rated the content as 5/5 while the other one participant rated the content as 4/5. All respondents commented that there was quite a bit of content on the website. Three respondents mentioned that the content was really difficult to understand. One respondent upon observation seemed to be frustrated with using the website.

## ***Navigation***

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### ***Parents***

Two users ranked the navigation as 2/5 while the other users rated the navigation as 3/5, and stated that the navigation is easy to use. All feedback suggested that it was difficult to find items. Two of the users felt that they did not know how to navigate between items. One of the respondents remarked that they would not be able to use the website if they had to use it again.

### ***Deaf and Hard of Hearing***

Three users rated the navigation as a 2/5 while one of the users rated the navigation as 3/5. Two users mentioned that the navigation was very difficult to figure out. One of the respondents mentioned that the navigation looked clustered.

## ***Usability***

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### ***Parents***

Three of the respondents rated the usability as a 3/5 while one respondent rated the usability as a 2/5. Parents expressed that they enjoyed using the website due to its familiarity and there is little worry about how to use it. However, at least three of the respondents reported that they were unsure about how to successfully use the website, even after five minutes of usage.

### ***Deaf and Hard of Hearing***

Three of the respondents rated the usability as 2/5 while the other one rated it as a 3/5. All respondents commented that the website was not user friendly.

## ***Connection and Communication***

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### ***Parents***

All of the users felt that the website could help them communicate with their child. Open-ended responses revealed that three of the users felt the website included much of the information they are looking for when trying to learn a sign. However, when asked about connection, three users reported that they did not feel the website can help them connect with their child. One of the users felt that the website could help them connect with their child. Responses related to connection, concluded that three of the users felt a website was a difficult platform to use with their children. They felt the website would not maintain the attention of their children. One of the users mentioned that their child was hyperactive and she was not sure how to even sustain his interest with the use of the website.

### ***Deaf and Hard of Hearing***

Two of the users felt the website could help them communicate with their child. All users felt that the website would not help them connect with their caregiver. Two respondents mentioned that the website is too confusing for both a parent and child to realistically learn from it. One of the respondents mentioned that the website is more parent-friendly and not appropriate for children. Three users mentioned the website is too confusing to allow connection between a parent and child.

Software application

## ***Excitement, Motivation, Entertainment***

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### ***Parents***

Three respondents reported that they were somewhat excited about learning sign

language when using the software application. One of the users reported that they were a little excited about learning sign language with the website. Three participants reported that using the application was somewhat motivational, while the other one reported that it was motivational. One respondent reported that the application was somewhat entertaining; two said the application was entertaining and another one stated that the application was very entertaining.

### ***Deaf and Hard of Hearing***

Two users reported that the application made them feel somewhat excited about learning sign language and the other two reported that the application made them feel excited about learning sign language. Two users reported that the application made them feel motivated about learning sign language while the other two reported that the application made them feel somewhat motivated about learning sign language. Three respondents said the application was entertaining and one said the application was very entertaining. Respondents did not have any negative feedback about their motivation, excitement or how entertained they felt when using the application.

### ***Design***

---

#### ***Parents***

Three users ranked the design as a 5/5 while the other one rated the design as 4/5. None of the respondents had any negative comments about the design. All the users mentioned that the design was very cute and perfect for children. One respondent very much enjoyed the music in the background.

#### ***Deaf and Hard of Hearing***

All of the users ranked the design as 5/5. All of the respondents commented that the

design was good for children. One member from the hard of hearing group expressed enjoyment at the music.

## ***Content***

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### ***Parents***

Two respondents rated the content as 3/5 while the other two participants rated the content as 4/5. Two of the respondents commented that understanding the content was intuitive and did not require a large amount of text to understand. Three respondents remarked that there was not much content to experiment with. This is likely due to the application being in a prototype form.

### ***Deaf and Hard of Hearing***

Three of the respondents rated the content as 3/5 while the other one respondent rated the content as 4/5. Three respondents mentioned that there was not much content to experiment with. Three of these respondents also remarked that they did not like the signer used in the prototype. A couple of the participants actually laughed at the signer and were curious about how he was chosen for the prototype.

## ***Navigation***

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### ***Parents***

All respondents ranked the navigation as a 4/5 and stated that the navigation is easy to use. All of the users mentioned that they enjoyed the navigation. Three of the users did remark that some features would take some time to learn. However, one of these users mentioned that the application was fun enough to try and figure out how to use it.

### ***Deaf and Hard of Hearing***

All respondents rated the navigation as 4/5. One user upon observation struggled with using the application and had a couple of questions pertaining to the learning and story mode. Two of the four respondents expressed that the navigation was simple to figure out.

### ***Usability***

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#### ***Parents***

All of the respondents rated the usability as a 4/5. Two respondents felt that it took longer than they would have expected to figure out how to use the program. However, after learning it they felt that it was really easy to use.

### ***Deaf and Hard of Hearing***

Three of the four respondents rated the usability as 4/5 while one of the respondents rated the usability as 5/5. One of the respondents mentioned that the application was a bit difficult to use at first. One respondent mentioned that it was difficult to judge the usability since it was not finished.

### ***Connection and Communication***

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#### ***Parents***

All of the users reported that they felt the application could help them communicate and connect with their child. Two responses mentioned that it would be fun to explore an environment with their child and receive visual feedback. One of the responses mentioned that it would be a good way to keep their child entertained and learning even without their presence.

### ***Deaf and Hard of Hearing***

Three users felt the application could help them communicate with their caregiver. Three of the users felt the application could help them connect with their caregiver. One respondent mentioned concern about a caregiver not enjoying the use of the application. Two of the respondents mentioned that the application may be better designed for children than parents. From my own observations, one of these participants seemed excited about using the application and thought it had the potential to be a great learning tool. However, this same participant expressed concern about the long term enjoyment of using the tool as a parent and that's in its current state, it would not retain the interest of a parent.

### **Comparison of Tools**

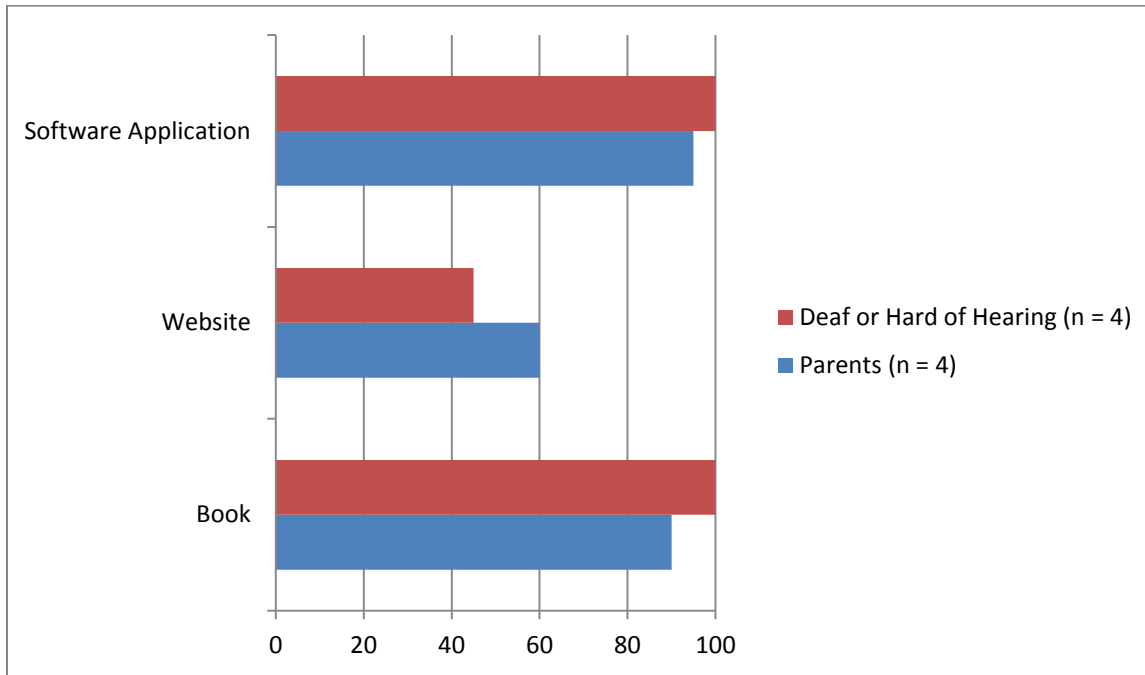
The following figures show a comparison of how each instructional tool was rated against the other for different components. Each tool had a 5-point Likert rating scale. Responses were recorded and then averaged.

### ***Design***

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Participants were asked to rate the design on a five point Likert scale from 1 (Bad) to 5 (Very good). Figure 13 shows how participants rated the designs of each instructional tool. Users overall rated the software application and book highly. Both hearing and deaf or hard of hearing

groups rated the website low on design.



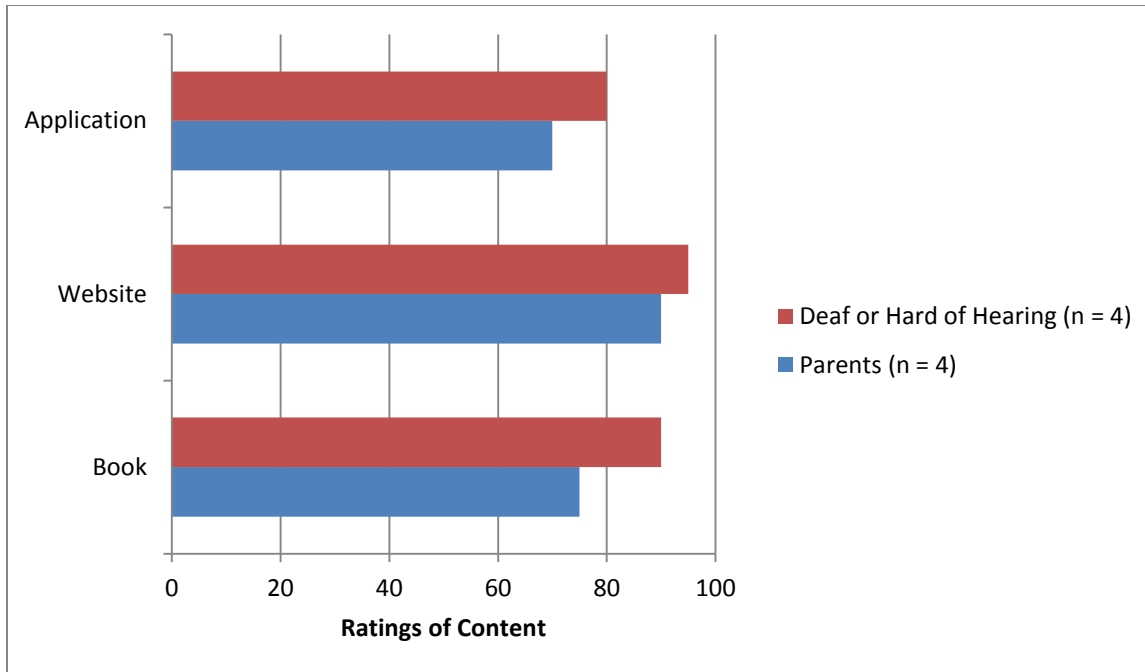
*Figure 13 Participants Rating of the Design. Participants responses are recorded with a five point Likert scale from 1 (Bad) to 5 (Very good). All of the responses are averaged and reported in the chart below.*

## ***Content***

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Participants were asked to rate how they liked the content from 1 (Bad) to 5 (Very good) for each instructional tool. Figure 14 shows the results of these ratings. The website had the highest rating. Users did feel the website offered good content. However, open-ended questions revealed that users were not satisfied with the presentation of the content. Users rated the book's content highly as well. Users rated the software application's content lower than both the book and website. Open-ended questions revealed that some users were not satisfied with the amount of content available in the prototype, and felt it was lacking.





*Figure 14 Participants' ratings about the content. Participants responses are recorded with a five point Likert scale from 1 (Bad) to 5 (Very good). All of the responses are averaged and reported in the chart below.*

## ***Navigation***

Participants were asked to rate how they liked the content from 1 (Difficult to Use) to 5 (Easy to Use) for each instructional tool. Figure 15 shows the results of these ratings. Both the software application and website are rated highly. The website is rated very low. Open-ended questions revealed that users were not satisfied with the navigation of the website and felt it did not meet their needs. Also note that table 4 includes ratings of all the design features for the book, website and software application. This table provides an overall perspective on the comparison of results.

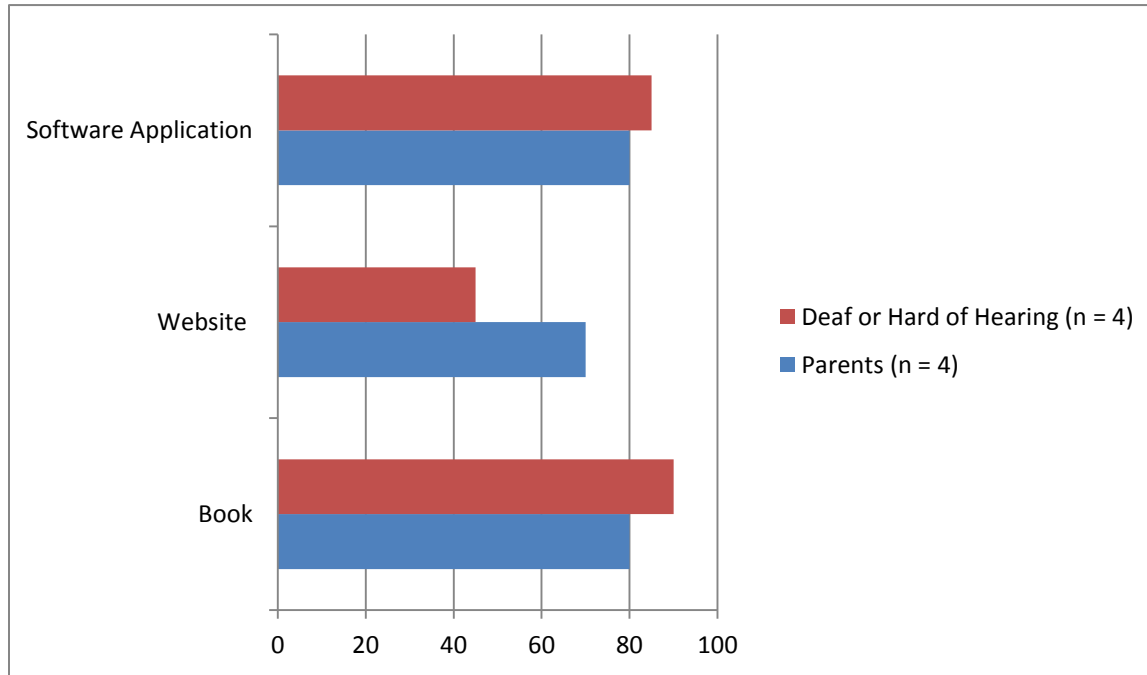


Figure 15 Participants' Ratings on Usability. Participants responses are recorded with a five point Likert scale from 1 (Bad) to 5 (Very Good). All of the responses are averaged and reported in the chart below

Table 4 Ratings of how each construct did with the book, website and software application. Please note the connection and communication are rated based on how many people said “yes” on the question.

Construct	Book	Website	Software Application
<b>Excitement, Motivation and Entertainment</b>	(mean = 3) ★ ★ ★	(mean = 2) ★ ★	(mean = 3.75) ★ ★ ★ ★
<b>Design</b>	(mean = 4.75) ★ ★ ★ ★ ★	(mean = 2.75) ★ ★ ★	(mean = 4.88) ★ ★ ★ ★ ★
<b>Content</b>	(mean = 3.88) ★ ★ ★ ★	(mean = 4.5) ★ ★ ★ ★ ★	(mean = 3.75) ★ ★ ★ ★
<b>Navigation</b>	(mean = 4.25) ★ ★ ★ ★	(mean = 2.3 ) ★ ★	(mean = 4) ★ ★ ★ ★
<b>Usability</b>	(mean = 4.25) ★ ★ ★ ★	(mean = 2.5) ★ ★ ★	(mean = 4.13) ★ ★ ★ ★

## Open Ended Questions about Tools

Participants were asked open-ended questions about things they liked and disliked about each learning tool. Table 5 shows their responses.

*Table 5 Likes and Dislikes About Learning Tools. Numbers in parentheses indicate the count of participants who made that comment.*

<b>Participant Type</b>	<b>Book</b>	<b>Website</b>	<b>Software Application</b>
<b>Parental Group (Likes)</b>	<ul style="list-style-type: none"> <li>• Design (4)</li> <li>• Familiarity of Using a Book (2)</li> <li>• Being able to look at an index and table of contents (2)</li> <li>• Clear pictures for signs (2)</li> </ul>	<ul style="list-style-type: none"> <li>• A large amount of content (3)</li> <li>• The ability to view videos of the signs (3)</li> <li>• Good reference tool (1)</li> </ul>	<ul style="list-style-type: none"> <li>• Design (4)</li> <li>• Interactivity (3)</li> <li>• The use of music (3)</li> <li>• The use of moving visuals (2)</li> <li>• Exploration (2)</li> </ul>
<b>Parental Group (Dislikes)</b>	<ul style="list-style-type: none"> <li>• Limited feedback (2)</li> <li>• Only can use with young children (2)</li> </ul>	<ul style="list-style-type: none"> <li>• The content is hard to read and understand (4)</li> <li>• Cannot navigate tool successfully (2)</li> <li>• Not helpful for children (2)</li> <li>• Cannot find a starting point (1)</li> <li>• Poor quality videos (1)</li> <li>• Hard to mimic signs (1)</li> </ul>	<ul style="list-style-type: none"> <li>• The signer is not friendly (4)</li> <li>• Lack of content (3)</li> <li>• Music is annoying (1)</li> <li>• Navigation is a bit difficult to understand (1)</li> </ul>
<b>Deaf and Hard of Hearing Group (Likes)</b>	<ul style="list-style-type: none"> <li>• Design (4)</li> <li>• Clear pictures for signs (4)</li> <li>• Fun to use (2)</li> </ul>	<ul style="list-style-type: none"> <li>• Viewing the videos of signs (4)</li> <li>• The content (3)</li> <li>• Explanations for the signs (2)</li> <li>• Diversity of signers (1)</li> <li>• Good reference tool (2)</li> </ul>	<ul style="list-style-type: none"> <li>• Design (4)</li> <li>• Interactivity (3)</li> <li>• Fun to use (3)</li> <li>• Content (2)</li> <li>• Exploration (1)</li> <li>• The use of music (1)</li> </ul>

<b>Deaf and Hard of Hearing Group (Dislikes)</b>	<ul style="list-style-type: none"> <li>• No feedback for user (2)</li> <li>• Easy to lose; Not accessible everywhere (1)</li> </ul>	<ul style="list-style-type: none"> <li>• Too much information (4)</li> <li>• Hard to understand written content (3)</li> <li>• Hard to mimic signs (2)</li> </ul>	<ul style="list-style-type: none"> <li>• The signer is not friendly (4)</li> <li>• Unclear about the story and learning mode (2)</li> <li>• Not enough content (2)</li> <li>• Cannot playback or slow down videos (2)</li> <li>• Music is annoying (1)</li> </ul>
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## CHAPTER 5

### Findings and Conclusion

The primary purpose of this study was to evaluate three common types of instructional tools that were used to learn sign language with hearing parents and deaf or hard of hearing children. Each instructional tool had a feature that another lacked, and had its own individual strengths and weaknesses. The evaluation questionnaires were meant to provide a qualitative measure on how hearing parents and deaf and hard of hearing users initially perceive different types of instructional tools.

One important component of using an instructional tool is how motivating and exciting it is. Both the parent and child may require motivation to use the tool as a long term solution for learning sign language. Questions were asked about the excitement, entertainment and motivating qualities of the tools to better gauge how motivational the tool was perceived. One question about motivation may not suffice, especially since users may define motivation differently. The results suggested that the software application would be more exciting, entertaining and motivational to use than the other platforms. However, many users expressed some motivation, excitement and entertainment value in the book. From the open-ended questions, users stated the importance of exploration, interactivity, clearness of how signs were presented and the overall design. These elements likely contributed to how they judged how entertaining, motivating and exciting each instructional tool was. Future research may involve asking more detailed questions about which portions of each learning tool are motivating to a specific group. Unfortunately, the limited information about what features of the tools were seen as motivating, entertaining, and exciting does not present a clear picture of why each user's response varied. Asking direct and detailed questions about why the tool is motivating, exciting

and entertaining could provide additional clarification on what specifically was motivating or exciting to the deaf or hard of hearing populace compared to a hearing parent. Furthermore, future research could ask questions related to intrinsic and extrinsic motivation for learning sign language, since both can play a large role in how a tool is perceived.

Design was also explored during the experiment. The results suggest that both the hearing parent and deaf or hard of hearing group highly valued how child-friendly the designs were. Both groups commented on how the designs from the book and software application were ideal for children. How the signs were portrayed was also valuable to the users. The users enjoyed the signs presented in the book mainly because the pictures were clear and understandable. Some users expressed enjoyment with the signs on the website. Participants explained that the signs were understandable and enjoyed the diverse and friendly-looking interpreters. Prior research discusses the importance of good visual design using Gestalt principles (Johnson, J., 2010, Chang, D., Laurence D., and Juhani E.T., 2002). The results are consistent with the research, showing that the book and software application followed a better visual design, while the website did not succeed in fulfilling user's expectations for visual design. Music was another positive factor that a user from both groups commented on with the software application. Future research could focus on music and how that can impact the experience of a hard of hearing child or hearing parent. Understanding the role of music with the deaf and hard of hearing populace and hearing parents can help a designer make a wiser choice about whether it should be included.

Questions were asked about the content of each instructional tool. Users reported satisfaction with the content of the website and book. The results suggested that an instructional tool should have good, understandable content. Although some users reported the book's content was a bit limited, all of the users agreed that the content was ideal for initially learning sign

language. The website had a large amount of content which users reported as making them feel like they could learn sign language at different stages in their knowledge. This is consistent with prior research (Oppermann, R, 2002) about the content conforming to a user's expectation. The content of the website and the book fit the user's expectation. The software application had limited content that did not conform to the user's assumptions.

The users ranked the navigation of the book and software application far higher than the website. Users reported issues with confusing information and not having some type of reference available. The navigation for the website did not make the user feel controlled or feel comfortable exploring the tool. This is consistent with prior research about navigation (Oppermann, R, 2002, Marcus, A., and Gould E.W., 2000, Johnson, J., 2010, Stefaner, M., et al., 2009). Users did rank the navigation highly for the book and software application. Their open-ended responses conveyed that the book was familiar to them. The application was challenging for some to figure out initially, but users felt more in control and free to explore after a few minutes of usage. Future research should perform usability testing that involves timing the task and recording clicks for digital content. This might provide further insight on the navigation of each learning tool.

In terms of usability, participants reported frustration at using the website. Participants from both the hearing parent and deaf and hard of hearing group were most focused on how quickly it is to use a tool. This thinking may have resulted from the groups only having five minutes to explore each tool on their own, therefore limiting the amount of time they need to figure out how to use the tool. Future research could allow participants additional time to actually use each learning tool.

Respondents ranked the book overall more highly in regards to connection and

communication. The results pertaining to connection are consistent with theories about the importance of books and storytelling when learning language (Peck, J., 1989, Sadik, A., 2008, Tsou, W. et al. 2006). These theories are also consistent with the results about the software application. One response from the deaf and hard of hearing group regarding level of connection with the software application was the interest of the caregiver. However, all of the users from the parental group expressed that they felt the application could help them connect with their children. The website was not consistent with the results. Future research would need to evaluate what specifically the website was lacking to rank so low on connection and communication. Users cited issues regarding the content, navigation and usability, but this may not be a direct correlation on the user's expectations for connection and communication.

These results address the first research question about the design requirements for a language learning system. This section identifies some of the necessary components for an instructional tool to successfully help deaf and hard of hearing users learn sign language with a hearing caregiver. These results also satisfy some parts of the second research question about what technological solutions address the social and linguistic needs of a deaf or hard of hearing child. The data show that the design requirements need to include the following:

1. The tool must encourage the user to learn sign language. The tool must guide the user to completing a task (i.e. learning a sign) and encourage the user to use the tool in the future.
2. The tool should incorporate familiarity into the design. Many users may be novices and using a tool for the first time. The book and software application were familiar to the user and utilized features that made the user feel comfortable exploring. Encouraging



exploration may also be helpful to children who need to learn a large amount of vocabulary and be a motivating component for both a caregiver and child. However, too many unfamiliar features may lessen the user's interest and make the first impression of the tool very stressful. It is important to find a good balance between familiar and unfamiliar features. Testing is necessary when incorporating any new feature to ensure that the user finds the feature to be useful and fun to explore.

3. Information should be clear, concise, legible and understandable to the user. Participants did not like the content of the website, mainly because of how it was presented. Many users may not know where to begin when finding information. Many parents may not understand which words are necessary to teach their children during early childhood. Information should be presented from beginning to advanced signs. The website did not list their information in a way where users knew which signs were for novices, which resulted in users feeling confused about how to progress. Ensure that it is clear to the user which signs they should be learning at their current stage of knowledge. Furthermore, perform testing on how clear each of the signs and gestures are. This is especially important when making the choice to use static signs. If the user does not feel that he or she can understand the signs, then that makes it far less likely that a user will develop literacy.
4. The design should be consistent in the tool. Users enjoyed the design of the book and software application because of its consistency. The website, however was inconsistent with how information is presented. Inconsistent designs could lead to confusion of the user. Depending on the medium, it would be good to test different designs with both a hearing caregiver and a deaf or hard of hearing child to better evaluate which designs are

most effective and understandable.

5. The tool should incorporate videos of the signs if possible. Users of the website and software application were more satisfied with having a video to watch rather than looking at a static picture of a sign. If the designer chooses to use a static picture, then usability testing will need to be performed to ensure the pictures are understandable to a deaf or hard of hearing user.
6. The tool should allow for control (Oppermann, R, 2002) whenever possible. Users reported the need for controlling playback of the video, decreasing or increasing the speed, and being able to turn off elements such as music. Allowing user control will allow the user to complete a task at his or her own pace.
7. The tool may want to incorporate storytelling. Users expressed the importance of feeling connected and finding their own method of communication with their children. There is evidence that storytelling (Peck, J., 1989, Sadik, A., 2008, Tsou, W. et al. 2006) helps literary development and encourages closeness with a caregiver. Storytelling may be an easy component to incorporate into digital learning tools. Storytelling could be a key component when addressing the third research question about how to establish connection as well as communication with a child.
8. Although not evaluated, the tool should incorporate feedback if possible. Prior instructional systems have been developed that use feedback. Having feedback may allow a user to feel more in control and confident in how he or she is learning sign language (Cavender, A.C., Bigham, J.P. & Ladner, R.E., 2009). Using a gesture feedback tool where the user could sign into a camera and have the system provide accurate feedback would be ideal. However, even a camera where users can see themselves sign and

compare themselves to a video would be helpful to a user.

9. Although not evaluated, the tool may need to celebrate deafness and view qualities of deafness or hard of hearing as positive qualities.
10. The tool may need to encourage diversity with signers. Users reported enjoyment at seeing a diverse range of signers with age, gender and race.

Further work is needed to better understand the relationship between the interpersonal connection of a child and caregiver, learning sign language and appropriate tools that can help encourage both of these elements. This study provides an evaluation of current instructional tools with the aim of helping designers to create or modify existing tools that help parents and deaf or hard of hearing children learn sign language successfully.

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## APPENDIX 1: Demographic Questionnaire

Please answer all questions accurately. This information will be kept completely confidential.

**Age:**

**Gender:** Female Male

**Major:**

**Minor:**

**GPA:**

**Ethnicity:** Asian American/Asian  
Black/African American  
Latino/Hispanic (nonwhite)  
Pacific Islander  
White/ Caucasian  
Other

**Year level** (circle closest one to your year in school): 1<sup>st</sup> 2<sup>nd</sup> 3<sup>rd</sup> 4<sup>th</sup>

**Mother's Education:** pick highest obtained (circle one):

High School Some College 2-year college degree 4-year college degree  
Masters Degree Doctorate (MD, Ph.D, etc.)

**Mothers Occupation:**

**Father's Education:**

High School Some College 2-year college degree 4-year college degree  
Masters Degree Doctorate (MD, Ph.D., etc.)

**Fathers Occupation:**

**Parents Income Level (circle one; best guess if not certain):** below 20,000; 21,000-40,000, 41,000-60,000, 61,000-80,000, 81,000-100,000, above 100,000

**Do you have any children?** Yes No

**Please list the ages of your children (if applicable)?**

**Deaf or Hearing**

Are you deaf, hard-of-hearing, or neither? Please circle one

If you are either Deaf or hard-of-hearing, please answer the following questions:

Did you become deaf at birth? YES NO

If no, when did you first experience the hearing loss? \_\_\_\_\_

What is the level of your Db-loss? \_\_\_\_\_

Is your parent(s) deaf? YES NO

Circle all that apply: Mother Father

Is your sibling(s) deaf? YES NO

Any of your immediate family members know sign language? YES NO

When did you first learn sign language? \_\_\_\_\_

Did you use sign language at home while growing up? \_\_\_\_\_

Did you go to residential school for the deaf that used ASL? YES NO

If so, how many years at residential school for the deaf? \_\_\_\_\_

Did you go to a mainstreaming school program for the deaf? YES  
NO

If so, how many years? \_\_\_\_\_

Did you have interpreting services? YES NO

Did other students use sign language at your school? YES NO

Did you socialize with other deaf students at your school? YES NO

Do you consider yourself as part of the Deaf community? YES NO

Do you have Cochlear Implants? YES NO

Are you still using it? YES NO

Do you have some types of hearing aid? YES NO

Primary mode of communication (circle one) Oral ASL Signed English

Do you prefer using sign language for expressive communication? YES NO

Do you prefer using sign language for receptive communication? YES NO

**Questions specifically for hearing parents (participants who checked yes to having children):**

Is your child deaf or hard-of-hearing?

Was your child deaf at birth? YES NO

When did you learn that your child was deaf? YES NO

Does your child know sign language? YES NO

Do you know sign language? YES NO

What computer technologies have you used to aid in communication with your child?

How have you benefited through use of these technologies?

How have these technologies helped you to bond with your child?

Which features of these technologies were difficult to use?

How do you think that they could be improved?

What computer technologies have you used for learning?

How did you benefit through use of these technologies?

Were any features of these technologies difficult to use?

How do you think these features could be improved?

Did you use books to help aid you with learning sign language?

Did you use websites to help aid you with learning sign language?

Did you use games to help aid you with learning sign language?

Did you use other applications to aid you with learning sign language?

If so, please list the applications that you used.

**Questions specifically for hearing-impaired adults (participants who checked that they were either deaf or hard-of-hearing)**

What computer technologies have you used to aid in communication with friends and family members?

What computer technologies have you used for learning?

How did you benefit through use of these technologies?

Were any features of these technologies difficult to use?

How do you think that they could be improved?

Did you use books to help aid you with learning sign language?

Did you use websites to help aid you with learning sign language?

Did you use games to help aid you with learning sign language?

Did you use other applications to aid you with learning sign language?

If so, please list the applications that you used.

## APPENDIX 2: Evaluation Questionnaire

This questionnaire is designed to ask questions about various aspects of the printed materials that you have used in this study. Please be as accurate as possible when completing these responses. Your responses to these questions will help us with identifying features most useful for teaching and encouraging the use of sign language in a family environment. Your responses will be kept confidential.

### Questions about content:

On a scale of 1 (Bad) to 5 (Very good), please rate the content:

What did you like about the **content** (i.e. exciting to read)?

What did you dislike about the **content** (i.e. could be broken down into chunks)?

### Questions about navigation:

On a scale of 1 (difficult to use) to 5 (easy to use), please rate the navigation:

What did you like about the **navigation** (i.e. easy to find)?

What did you dislike about the **navigation** (i.e. navigation could be simplified)?

### Questions about design:

On a scale of 1 (Bad) to 5 (Very good) please rate the design:

What did you like about the **design** (animation, characters, color, layout)?

What did you dislike about the **design** (animation, characters, color, layout)?

What are some improvements you would like to see?

### Questions about communication and connection:

#### For Parents

Do you feel that use of the printed materials will help you to communicate more effectively with your child? Please explain

Do you feel that use of the printed materials will help you to connect more with your child?

Yes No (Please explain)

#### For Non-Parents

Do you feel that use of the printed materials will help you to communicate more effectively with your caregiver? Please explain

Do you feel that use of the printed materials will help you to connect more with your caregiver?

Yes No (Please explain)

### Questions About Motivation

Do the printed materials make you more excited about learning sign language?

1 - not excited, 2 - a little excited 3 - somewhat excited, 4- excited 5 - very excited

Do the printed materials motivate you to want to learn sign language?

1 - not motivational, 2 - a little motivational 3 - somewhat motivational, 4- motivational 5 - very motivational

How entertaining are the printed materials?

1 - not entertaining, 2 - a little entertaining 3 - somewhat entertaining, 4- entertaining 5 - very entertaining

Please explain