Signing Math & Science Dictionary Apps for Inclusion of Deaf and Hard of Hearing Visitors in Science Museum Exhibit Activities

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Abstract

This paper discusses implementation research conducted by TERC, Inc., at the Museum of Science (MoS) in Boston. Purposes of the research were to examine how visitors ages 5 through adult, who are deaf or hard of hearing and communicate in sign language, integrate mobile versions of a Signing Science Dictionary (SSD), Signing Science Picture Dictionary (SSP), and Signing Math Dictionary (SMD) into their museum experience during family visits, and to study the impact of the dictionaries' use. Developed by TERC and Vcom3D, each dictionary includes approximately 700 terms and is intended to enable increased access to information through individualized use. While the results of this research reflect the experiences of a limited number of families in a single informal setting, the data strongly support the assertion that the dictionaries are valuable assistive tools when used during science museum visits.

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Introduction

This presentation will provide a snapshot of what can happen when family visitors, ages 5 through adult, who are deaf or hard of hearing and communicate in sign language, use mobile versions of a Signing Science Picture Dictionary, Signing Science Dictionary, and Signing Math Dictionary during visits to the Museum of Science, Boston (MoS). A run-through of the unique features of each dictionary will highlight the Universal Design for Learning (UDL) framework that underlies each app and has proven essential for meeting the varied communication needs of visitors who are deaf or hard of hearing and use sign for communication. Focusing on the Word Lists attached to exhibit panels, it will be explained that even with all of their options for individualized use, simply providing a versatile tool without a mechanism to help begin using it can be a less than ideal solution. Summary data from the larger study that provided the excerpts used for this presentation will show that the apps can help visitors to: read instructions and labels, look up the ASL signs for and definitions of exhibit terms, and then use the sign and their new learning to discuss the science content that is the focus of the exhibit.

The implementation research that is discussed in this paper was conducted by TERC, Inc. at the Museum of Science (MoS) in Boston in partnership with a team from the MoS. Its objectives were 1) to examine how visitors who are deaf or hard of hearing and who communicate in sign language integrate iPod Touch versions of a Signing Science Pictionary (SSP), Signing Science Dictionary (SSD), and Signing Math Dictionary (SMD) into their experience during family visits to the museum, and 2) to study impact of the dictionaries' use.[48] To accomplish our research objectives, two questions guided our study: 1) How do visitors, ages 5

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through adult who are deaf or hard of hearing, integrate mobile dictionaries into their museum learning experiences during family visits? 2) What kinds of learning are made possible with use of the dictionaries, and how do they affect the engagement, involvement, and interest of these visitors during family visits to the museum?

Although persons who are deaf or hard of hearing are not necessarily considered "print disabled," those who acquire and use sign language to communicate tend to internalize a linguistic structure that differs greatly from English. This results in significant literacy limitations that lead to the majority of deaf students leaving high school with reading levels at the fifth grade or below (Karchmer & Mitchell, 2006). Also, for this population, museum visits tend to be a low priority, as a wealth of information is presented as written text, and often there is scant provision for its interpretation in sign language (Proctor, 2005).

Figure 1: Tia, One of the Signing Avatars

Developed by TERC and Vcom3D, each of the dictionaries is a complete assistive tool that includes approximately 700 science or mathematics terms.[49] The SSP, SSD, and SMD contain signing avatars, as shown in Figure 1, and a range of interactive features that result in each dictionary incorporating the principles of the Universal Design for Learning (UDL) framework. The framework emphasizes three key aspects of pedagogy: multiple means of representing information, multiple means for expression of knowledge, and multiple means of engagement (Rose, Hasselbring, Stahl, & Zaballa, 2005; Rose & Meyer, 2006). Integration of these interactive features was intended to offer deaf and hard of hearing users increased access to information through individualized use.

Before beginning the study, the team selected the museum exhibits to use for data collection. Criteria for selection were that lighting was sufficient to view signing, audio components were presented as text and/or graphics, topics were appropriate for a broad age range, key terms were included in the dictionaries, and a choice of STEM topics was offered. Two exhibits met these criteria and were selected as settings: *Science in the Park*, where visitors use playground equipment to investigate force and motion, and *Take a Closer Look*, where visitors exercise their powers of perception to explore the science that is inherent in their observations.

Methods

With our research questions serving as the framework, we implemented a three-step within-subjects mixed methods design that integrated qualitative and quantitative methods (Cresswell & Plano Clark, 2011; Johnson, Onwuegbuzie, & Turner, 2007). This three-step protocol, described below, resulted in a "full variety of evidence" (Yin, 2009) that was used for analysis.

1. Pre-visit—Parents completed a *Family Information Form.* It provided demographic information that was used to assign families with younger children to *Science in the Park* and families with older children to *Take a Closer Look*.

2. The Visit—We met with families at the entrance to their assigned exhibit; we gave them iPods with the dictionaries installed and instructed visitors in their use. Using a randomization procedure that involved a coin toss, we assigned the first family either to begin their visit with at least two activities with Word Lists of relevant terms from the dictionaries that we had posted on the activity panels, or to begin their visit with activities that had no posted Word Lists. After the first group's destination was established, family assignments alternated between beginning activities with posted Word Lists and beginning activities without

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Word Lists. Thus, the initial coin toss determined the random assignment of the first family and of subsequent families. We observed family members as they engaged with activities, recording our observations in an *Observation Log*.

3. Post-visit—We met with families at the end of the exhibit and used an *Interview Form* to complete an exit interview. Families later returned a *Follow-Up Online Survey*.

Purposeful sampling (Patton, 2002), which we employed to ensure that each family included one child who was deaf or hard of hearing and used sign for communication, resulted in 10 family groups who provided us with data. These families included 10 deaf or hard of hearing children, ranging in age from 5 to 16, and also included one deaf father. Children's hearing loss ranged from severe to profound. Their signing skills ranged from novice to superior. The father had profound hearing loss and was a superior signer.

Data were analyzed as follows: To identify patterns, we developed a coding scheme of primary codes organized by research question and secondary codes organized by sub-questions. We then coded the evidence (Neuman, 1997). A single researcher collected and coded data, eliminating the need to develop a process for reliability among multiple coders. We used Nvivo software for analysis of interview transcripts to determine meaningful patterns that we could connect to our research questions (Patton & Applebaum, 2003). Cross-family analyses enabled us to see how our audience used the dictionaries and to find out about learning and engagement.

Results

To help us answer our first research question, we organized our results around four sub-questions: 1) What do family groups do with the dictionaries during their visit? 2) Why do visitors use the dictionaries to look up science and math terms? 3) Which dictionary features do visitors use to acquire information? 4) What are visitors' perspectives and opinions about using the dictionaries? These results are summarized below.

Observation and exit-interview data showed that family groups used the dictionaries during their visits to read instructions and labels, look up terms, use the ASL signs, and engage in discussion. Parents used the dictionaries to learn new signs for terms so they could better communicate with their children and answer their questions. Prompting from parents and seeing terms in the posted Word Lists encouraged children to look up particular terms.

Parents, deaf or hard of hearing children, and hearing children most frequently used the dictionaries to look up terms in ASL. The next most frequent reason was to look up definitions: if visitors looked at terms signed in ASL, they also looked at definitions in ASL. If they read the English version of terms, they also read definitions in English. Parents and hearing children looked up terms and definitions in English more frequently than children who were deaf or hard of hearing did.

Evidence from observation and exit-interview data also pointed to the value of posting Word Lists. Family groups that visited *Science in the Park* looked up terms at 86% of the activities with lists. Approximately three-quarters, or 77%, engaged in discussions about the activities using their new signing vocabulary at activities with lists and at 56% at activities without. At *Take a Closer Look,* groups looked up terms at 100% of the activities with lists and at 55% without; 82% read instructions at activities with lists and at 57% without; 70% read labels at activities with lists and 57% without.

As shown in Table 1, evidence from exit-interview and follow-up survey data provided information about how parents, deaf or hard of hearing children, and hearing children used the range of interactive dictionary features available to them to acquire information individually according to their unique and varied needs. They commented orally and in writing that they liked having a lot of features from which to choose and could do so without getting "bogged down" in the technology. Several particularly liked being able to control the speed of the avatar's signing and found being able to slow it down very handy in making sure that they knew how to correctly sign terms.

Table 1. Museum Visitors' Use of the Dictionaries' Interactive Features

Dictionary Feature	Parents (N=10)*	Deaf or Hard of Hearing Children (N=10)	Hearing Children (N=10)
Terms in ASL	10/10, 100%	8/10, 80%	4/4, 100%
Definitions in ASL	7/10, 70%	7/10, 70%	2/4, 50%
Terms in English	4/10, 40%	1/10, 10%	2/4, 50%
Definitions in English	5/10, 50%	2/10, 20%	2/4, 50%
Terms in Signed English	1/10, 10%	0	0
Definitions in Signed English	1/10, 10%	0	0

*- This number represents the 10 families that completed the Follow-up Survey.

Evidence from exit interview and follow-up survey data supplied additional information about visitors' perspectives and opinions. Parents who responded to the follow-up survey said the dictionaries were easy to use. They found them interactive, the selection of words extensive, and the avatars easy to understand. Ten (100%) parents found the dictionaries' contents informative; nine (90%) said the dictionaries were useful; eight (80%) said they made the visit easier for them; and seven (70%) said they afforded better access to the exhibits. Parents' interview comments focused primarily on the usefulness and value of the dictionaries in supporting communication with their children about the activities. They unanimously endorsed the Word Lists. They used the lists to identify words to look up and commented that the lists motivated them to use the dictionaries, integrate them into activities, and target the focus of their use.

To help us answer our second research question, we organized our results around three sub-questions: 1) How much time do family groups spend at activities? 2) What do family members learn with use of the dictionaries? 3) What do family members say about use of the dictionaries and their level of engagement, involvement, and interest? These results are summarized below.

Observation data provided evidence about the amount of time visitors spent at activities with and without Word Lists:

> *Science in the Park*—5% spent <1 minute at activities with Word Lists, 41% spent 1-2 minutes, and 54% spent >2 minutes. 11% spent <1 minute at activities without Word Lists, 44% spent 1-2 minutes, and 44% spent >2 minutes.
>
> *Take a Closer Look*—0 spent <1 minute at activities with Word Lists, 33% spent 1-2 minutes, and 67% spent >2 minutes. 0 spent <1 minute at activities without Word Lists, 38% spent 1-2 minutes, and 62% spent >2 minutes.

Nearly all of the groups spent at least 1 minute at an activity, and half spent at least 2 minutes. Visitors spent more time at *Take a Closer Look* than at *Science in the Park*. This difference is likely due to two factors: 1) Older children who may have had longer attention spans were assigned to *Take a Closer Look*. *2)* The kinesthetic playground nature of *Science in the Park* may have motivated children to want to move from activity to activity so that they could play at each. Numerous studies have shown that visitors generally use interactive exhibits for about 1 minute or less (e.g., Diamond, 1986; Gutwill, 2005). Therefore, the duration of time spent at the museum activities further indicates that dictionary use contributed to engagement, involvement, and interest. Figure 2 shows children at a *Science in the Park* activity.

Figure 2: Family Group Members at a *Science in the Park* Activity

Exit interview data, reinforced by observation data, indicated that the dictionaries resulted in family members learning new signs and definitions for terms. A most salient finding was that families were observed using newly acquired signed vocabulary during discussions that took place as they visited activities. By extension, there is strong suggestion from these findings that dictionary use can lead to engagement, involvement, and interest of our audience members in museum visits.

Parents' comments, as in the examples that follow, provided additional insight into the types of learning that occurred with use of the dictionaries: "I learned new words in ASL." "In math, *frequency* means one thing. In science, it means something else. This led to a rich conversation with my kids about multiple meanings as we learned about ultraviolet light and the light spectrum." "The dictionaries helped my hearing children learn more ASL." "I learned the signs for *force* and *lever*." "My niece learned a few new signs." "My children learned the signs for *Earth, stars, lemon,* and *temperature.*" "I learned the sign for *vibration*."

In the post-exit interviews, children were asked to name a term they encountered in an activity and explain why they chose it. Their responses, as shown in these examples, indicate that the dictionaries supported children's learning of new signs and definitions: "At the seesaw, we looked up *lever* and *fulcrum.* I didn't know the sign for *lever* before." "I learned signs for some words like *nerve* and *reflect*." "I looked up *sonar* and learned what sonar is." "Knowing the sign and meaning for *reflect* helped me understand and explain to my mother what was happening with the light." More than half of the children (56%) said they looked up terms because their parents asked them to or because their parents prompted them indirectly to do so. Nearly half of the children (44%) said they looked up terms because they were on Word Lists.

Conclusions

Family visitors with a range of ages and levels of hearing loss used the dictionaries to learn the signs and definitions for terms that were new to them as they visited activities. They then engaged in discussions related to the activities. In the context of the two exhibits used for the study, the data strongly support the assertion that the dictionaries are valuable learning tools for science museum visitors who are deaf or hard of hearing.

It would be important to conduct further studies in more exhibits at the MoS as well as in additional museum venues such as zoos, aquariums, and natural history museums to confirm a broader applicability of the dictionaries as learning tools in other kinds of settings. It would also be useful to conduct additional studies to begin to ascertain the degree to which increased vocabulary knowledge might be a factor that enables increased content knowledge—a topic about which little is known.

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