Signing High School Science
(NSF, Grant #DRL-1019542)

Evaluation Report: App Versions of the Signing Life Science and Signing Physical Science Dictionaries

Spring 2015

Project Description

The evaluation findings reported here focus on the Signing Life Science Dictionary (SLSD) and Signing Physical Science Dictionary (SPSD) Apps, developed by TERC and Vcom3D and funded, in part, by the National Science Foundation, Grant #1019542. The SLSD and SPSD are being developed to serve the approximately 36,000 students in grades 9-12 who are deaf and hard of hearing and are required under the Individuals with Disabilities Education Act (IDEA) and No Child Left Behind Act (NCLB) to have access to the same content as hearing students. For use with an iPod Touch, iPhone, and iPad, the SLSD and SPSD apps are complete universally designed assistive tools that can be used independently of the curriculum in place. Each illustrated interactive dictionary has an audio component and includes ~750 standards-based terms in English and Spanish text that can be signed or listened to on demand. An animated interactive viewer—the SignSmith® player—allows users to select from a range of Avatar characters with different personalities and facial expressions; to adjust the speed of signing; and to sign a selected word, its definition, or part of speech in American Sign Language (ASL) or as a word-for-word translation (Signed English [SE] or Signed Spanish [SP]).

Goals and Research Questions

The primary intent of the field-test evaluation was to begin to establish effectiveness of the SLSD and SPSD Apps. A secondary intent was to find out about usability and teachers' and students' likes and dislikes. To begin to establish effectiveness, the partners investigated two research questions: 1-What kinds of learning gains in life science are possible with use of the SLSD? 2-What kinds of learning gains in physical science are possible with use of the SPSD? Extrapolating from findings from evaluation of their signing science and math dictionaries for students in grades K-8, the partners' hypothesized that with the SLSD and SPSD, students will have assistive tools that help them 1) increase their ability to recognize, sign/fingerspell and/or voice, and use the vocabulary of life and physical science; 2) improve their science content knowledge as reflected in their increased knowledge of the meaning of terms.

Research Design

A mixed measurement pre- post design that combines quantitative and qualitative methods in which the outcome of interest was measured for participants only was used to ascertain the types of learning gains that are possible with use of the SLSD and SPSD. Findings in this report address learning outcomes related to vocabulary knowledge as demonstrated by changes in students' ability to recognize the English text version of each of five terms identified by the teacher as critical for mastering the content of the unit of study selected for the test; to sign/fingerspell and/or voice each term; and to use each term in a sentence. Findings address learning outcomes related to content knowledge as demonstrated by changes in students' ability to define or explain the meaning of the terms. Qualitative feedback were supplied via written post-unit teacher and student surveys and analyzed to discern what teachers and students gained over the course of using the SLSD and SPSD and their thoughts about usability. During use observation and documentation from teachers provided insight into how they incorporated the dictionaries into instruction.

Instrumentation and Data Management

The research instruments used for data collection are described below. They were sent as an email attachment to teachers along with an introductory letter that described the research protocols as a series of steps that participants could check off as they completed each item. Teachers sent the completed instruments to TERC in hard or soft copy, based on preference, where the data were entered into spreadsheets, cleaned, and analyzed.

- **Site Data Form –** provides information about the school, teacher and students and is completed prior to teaching the unit selected for the study.
- **Pre-use Vocabulary Assessment Form** – provides information for assessing each student's pre-use knowledge of the five terms identified.
- **Post-use Vocabulary Assessment Form** – provides information for assessing each student's post-use knowledge of the five terms.
- **Post-use Survey -** provides feedback about teachers' and parents' experiences in using the SLSD and/or SPSD as an assistive tool.
- **Student Post-use Survey -** provides feedback about students' experiences with the dictionaries.

Participants

The evaluation was coordinated by TERC and included teachers solicited from a pool of middle and high school teachers of students who are deaf and hard of hearing with a range of hearing loss who taught in specialized schools for the deaf. Sources of teachers for the pool included the database of sites the TERC team had established for use with other Signing Math & Science projects, MADeafTerp Yahoo group listserv, EDUDEAF, and solicitations at conferences such as NSTA and Closing the Gap.

The test involved a single cohort of students. Data collection began in January 2015 and ended in May 2015. Characteristics of the groups that made up the cohort of test participants are presented in Table 1. Characteristics of the students are presented in Table 2. This information was gathered from the Site Data Form submitted by each teacher before beginning the study. The cohort included one student who used the apps at home with her parents. The data collection instruments were adapted to reflect home use of the dictionaries. In support of TERC's policies for working with human subjects, identifiers have been removed to ensure confidentiality.

Table 1. Participant Groups (N=6)

Group	Grade	Subject Area	School Type	Region	Setting	Teacher's Hearing Status	Teacher's Signing Level
I	10-11	Chemistry	School for the Deaf	Northeast	Urban	Hearing	Advanced
II	11-12	Chemistry	School for the Deaf	Midwest	Urban	Hearing	Advanced
III	6-8	Life Science	School for the Deaf	Northeast	Suburban	Hearing	Advanced
IV	6 & 8	General Science	School for the Deaf	South	Suburban	Hearing	Advanced
V	6-7	General Science	School for the Deaf	Northeast	Suburban	Hearing	Advanced
VI-Parent	6	General Science	Home Use	Northeast	Suburban	Hearing Parent	Intermediate

Table 2. STUDENTS (N=39)

Group	N	English Reading Level	English Writing Level	Hearing Status/Onset	Hearing Loss Level (best ear)***	Signing Level
I	5	**5** Below Grade	**5** Below Grade	**2** Deaf/<3 **2** Deaf with CI <3** **1** HH with Hearing Aid/<3*	**2** Profound **3** Moderate-Severe	**2** Advanced **2** Intermediate **1** Survival
II	5	**1** Below Grade **2** At Grade **2** Above Grade	**1** Below Grade **2** At Grade **2** Above Grade	**1** Deaf/<3 **2** HH with CI/<3 **2** HH with Hearing Aid/<3	**1** Profound **3** Moderate-Severe **1** Moderate	**1** Superior **1** Advanced **3** Intermediate
III	9	**9** Below Grade	**9** Below Grade	**1** Deaf with Hearing Aid/<3 **2** HH with CI/<3 **1** HH with CI/>3 **2** HH with Hearing Aid/<3 **3** HH with Hearing Aid/>3	**1** Profound **4** Severe **1** Moderate-Severe **3** Moderate	**8** Intermediate **1** Survival
IV	17	**12** Below Grade **4** At Grade **1** Above Grade	**13** Below Grade **4** At Grade	**8** Deaf/<3 **2** Deaf with CI/<3 **4** HH/<3 **1** HH with CI/<3 **2** HH with Hearing Aid/<3	**6** Profound **3** Severe **5** Moderate-Severe **3** Moderate	**6** Advanced **8** Intermediate **3** Survival
V	2	**2** Below Grade	**2** Below Grade	**2** HH with Hearing Aid/<3	**2** Mild	**2** Survival
VI	1	**1** Below Grade	**1** Below Grade Level	**1** Deaf <3	**1** Profound	**1** Advanced

* HH=Hard of Hearing ** CI=Cochlear Implant *** Without CI or Hearing Aid

Procedure

The research procedure involved placing the dictionaries in the designated classroom context with students who are deaf and hard of hearing at their intended grade levels. The intent of the research was to examine effectiveness under normal use conditions. To this end, each teacher identified at least one science unit to teach using the SLSD and/or the SPSD. This was something that the teacher ordinarily taught. The only difference was that they used the SLSD and/or the SPSD as an assistive tool. The teacher also identified 5 terms that were important for developing an understanding of the content that was the focus of the unit. Each of these terms had to be in the SLSD or SPSD. The parent focused on the topic the student was studying in school at the time of the test and on the terms he was expected to know. Using the assessment forms described previously, the teacher and parent then assessed each student's pre- and post-unit ability to recognize; sign/fingerspell and/or voice each term; explain its meaning and/or define it; and use each term in a sentence. Table 3 specifies the unit topics and key terms that teachers and the parent used for the study.

Table 3. UNIT TOPICS and KEY TERMS

Group	Unit Topic	Key Terms
I	Chemistry of Hot Peppers	chemical, chemical compound, body, taste bud, disease
II	Atomic Structure	atomic structure, valence electrons, electron dot structure, excited state, ground state

III	Heredity and Evolution; Classifying Organisms	evolution, mutation, homologous structure, gamete, population, kingdom, microorganism, cilium (cilia), decomposition, parasite
IV	Geologic Time; Weather	adapt, extinct, species, variation, common ancestor, temperature, UV light, freezing point, evaporate, Celsius scale
V	Mixtures and Solutions	solution, solvent, solute, dissolve, concentration
VI	Biology & Plant Cells	biology, organism, tissue, cell, nucleus

Results

Pre- Post-unit Vocabulary Knowledge—Each group showed pre- to post-unit improvement, on average, in the groups' ability to recognize the English text versions of the terms; sign/fingerspell and/or voice the terms; use each of the terms in a sentence; and explain the meaning of and/or define the terms. Tables 4-5 show this improvement as the mean pre-unit, post-unit, and pre- to post-unit change in ability for the number of positive (yes) responses out of the total possible. Table 6 provides this information as the average score for the group out of a maximum score of 3. A score of 3 represents accurate and complete ability to explain the terms' meanings/definitions. A score of 0 represents no answer. A score of 1 represents familiarity with the terms but no knowledge of their meanings/definitions. A score of 2 represents incomplete knowledge of the meanings/definitions.

Table 4. ABILITY to RECOGNIZE ENGLISH TEXT VERSIONS (N=39)

Group	N	Dictionary	Mean Pre-Ability	Mean Post-Ability	Mean Pre-Post Change
I	5	SLSD & SPSD	20/25 (80%)	25/25 (100%)	5/25 (+20%)
II	5	SPSD	7/25 (28%)	25/25 (100%)	18/25 (+72%)
III	9	SLSD	21/45 (47%)	39/45 (87%)	18/45 (+40%)
IV	17	SLSD & SPSD	55/85 (65%)	85/85 (100%)	30/85 (+35%)
V	2	SPSD	4/10 (40%)	8/10 (80%)	4/10 (+40%)
VI	1	SLSD	1/5 (20%)	5/5 (100%)	4/5 (+80%)

Table 5. ABILITY to SIGN/FINGERSPELL and/or VOICE TERMS (N=39)

Group	N	Dictionary	Mean Pre-Ability	Mean Post-Ability	Mean Pre-Post Change
I	5	SLSD & SPSD	20/25 (80%)	24/25 (96%)	4/25 (+16%)
II	5	SPSD	25/25 (100%)	25/25 (100%)	0/25 (+0%)
III	9	SLSD	10/45 (22%)	31/45 (69%)	21/45 (+47%)
IV	17	SLSD & SPSD	39/85 (46%)	83/85 (98%)	44/85 (+52%)
V	2	SPSD	6/10 (60%)	9/10 (90%)	3/10 (+30%)
VI	1	SLSD	1/5 (20%)	5/5 (100%)	4/5 (+80%)

Table 6. ABILITY to EXPLAIN the MEANINGS and/or DEFINITIONS (N=39)

Group	N	Dictionary	Mean Pre-Ability	Mean Post-Ability	Mean Pre-Post Change
I	5	SLSD & SPSD	1.5/3	2.0 /3	0.5/3 (+17%)
II	5	SPSD	0.5/3	2.7/3	2.5/3 (+18.5%)
IIII	9	SLSD	0.7/3	1.9/3	1.2/3 (+37%)
IV	17	SLSD & SPSD	1.1/3	2.5/3	1.4/3 (+44%)
V	2	SPSD	0.8/3	2.3/3	1.5/3 (+53%)
VI	1	SLSD	0.3/3	2.2/3	1.9/3 (+63%)

Use, Effectiveness, Likes and Dislikes— Tables 7 and 8 summarize the information from the written surveys. Since participants used the SLSD and SPSD interchangeably, the

information in the tables applies to both dictionaries. Table 7 summarizes the teachers' and parent's perspective. Table 8 summarizes the perspective of students.

Table 7. Teachers' and Parent's Perspective About Use and Effectiveness (N=6)

Questions	Teachers' and Parent's Responses
1. Which signing dictionary(ies) did you use as the primary dictionary(ies)?	SLSD & SPSD (2) SLSD (2) SPSD (2)
2. How would you rate students' ability to find information in the signing dictionary?	Very easy (3) Fairly easy (2) Possible with a little trial and error (1)
3. How would you rate your students' ability to use the signing dictionaries independently?	Requires no assistance (4) Requires some assistance (2)
4. How would you rate the signing dictionary as a resource that complements and enriches instruction?	Very valuable (5) Valuable (1)
5. When did your students use the signing dictionary?	With a science activity (3) To learn unfamiliar or new vocabulary (6) To review vocabulary (6) For homework or research (3) With a guided reading activity to be able to understand text that incorporated much technical vocabulary (1)
6. How did your students use the signing dictionary?	To learn the definitions of words (5) To learn new signs or see terms signed (6) To be able to discuss and explain something (5) To help them understand written information (4) To help them do their homework (3) To help them communicate in English or Spanish (1)
7. How did your students look at words and definitions?	Looked at words and definitions in ASL (6) Looked at words and definitions in SE (2) Looked at words and definitions in English (5) Listened to voiced words and definitions in English (2)
8. Which features did your students use?	They looked at illustrations (4) They selected an Avatar character (4) They changed the signing speed (6) They zoomed in on the avatar and/or rotated it (5) They changed the size of the text (2)
9a. How satisfied were you with the information available for each term? 9b. How satisfied were you with the accuracy of the signs? 9c) How satisfied were you with understanding the Avatar with the English text?	9a) Completely satisfied (4); Somewhat satisfied (2) 9b) Completely satisfied (4); Somewhat satisfied (2) 9c) Completely satisfied (5); Somewhat satisfied (1)
10. How did you use the signing dictionaries?	My students read an article on the chemicals that cause a pepper to be spicy. I identified 5 key words that they needed to understand in order to comprehend the article. They also used the signing dictionaries while reading to look up additional terms they did not understand. With my daughter as she was doing homework or studying for an exam to see if there was a sign for a word or if it was finger spelled. Vocabulary building and in class use during lab reports. Studying Life Sciences - Evolution and Organism Kingdoms.

	To introduce new vocabulary, to review vocabulary, and to explore how to sign or define words that they are somewhat familiar with. I used the signing dictionaries to ensure that correct signs were taught in class, to allow students to review vocabulary terms we were studying, and to help students develop their ability to independently find information.
11. Describe the benefits of using the signing dictionaries.	Students will use signing avatars for national and state testing. This is a fun way to infuse practice using this technology in the classroom. My students prefer using digital dictionaries to using traditional paper dictionaries/textbooks to define unfamiliar terms. Using the signing dictionaries increases student motivation to complete vocabulary tasks. The signing dictionaries have all the language modalities in one - ASL, written English, Spoken English, SE. I don't lose student attention/waste time by changing to different resources because the language needs of all my students are met in one place. Being a parent this is a great tool to learn the sign and definition to help my daughter with homework. There were times we would both learn the sign together. It also helped me to learn the proper way to sign the definition and have a better conversation about the science topics she was studying. The students were willing to study more and showed greater understanding. Very easy access to signs. It had many words that other dictionaries did not have. Novelty of new technology held students' interest. Exploring on their own they discovered how to change the Avatar or the speed and felt proud of themselves. They were excited about it. The signing dictionaries are a wonderful resource in the classroom and for homework. Our challenge was that they were only downloaded on the school iPads which were not available when students completed homework. Providing the definition, illustration, sign and explanation of definitions helps students link all the pieces and develop a better understanding of the vocabulary.

Table 8. Students' Perspective About Use and Effectiveness (N= 37)

Questions	**Students' Responses**
1. How easy for you was it to find information in the signing dictionary?	Very easy (23) Fairly easy (11) Somewhat difficult (1) Possible with a little trial and error (1) Impossible (1)
2. How easy was it for you to use the signing dictionaries without help?	I didn't need any help (19) I needed some help (16) I needed a lot of help (2)
3. How helpful were the dictionaries?	The dictionaries helped me a lot (25) The dictionaries help me a little bit (10) The dictionaries didn't help me at all (2)

4. When did you use the dictionaries?	To learn new signs or see words signed (30) To learn more about science (23) To be able to discuss and explain something (20) To help me understand written information (9) To hear the definitions and learn what they mean (16) To be able to communicate in English (15) To help me do my homework (7)
5. How did you look at and/or listen to words and definitions?	I looked at words in ASL (33) I looked up words in SE (10) I looked up words in English (20) I listened to words voiced in English (13)
6. Which features did you use?	The ASL button (31) The SE button (13) Voice icon (7) Looked at illustrations (19) Changed the signing speed (27) Selected an Avatar character (20) Zoomed in on the Avatar and/or rotated it (22) Changed the size of the text (8) Used English only (22) Used Spanish only (1) Used a combination of English and Spanish (1)
7. How did you find terms in the dictionaries?	I typed words into the search box in English (27) I typed words into the search box in Spanish (2) I used the "alphabet bar" to click on the first letter of the word that I was looking for, and then found the word in the letter list (23) I clicked on words within the definition to see them signed (18) I clicked on words below the line that were also included in the dictionary, to see them signed and defined (23)
8. Would you like to use the dictionaries again at school or at home?	Yes (32) No (5)
9. Using the signing dictionaries was fun.	Agree (32) Disagree (5)
10. Using the signing dictionaries made it easier to learn science words and definitions.	Agree (35) Disagree (2)
11. Using the signing dictionaries helped me to learn on my own.	Agree (31) Disagree (6)
12. Did you use the dictionaries to learn new signs?	Yes (28) Biology, nucleus, tissue, stores, evolution, species, cilia, plant, flagella, parasite, dissolve, solute, solvent, concentration, solution, decomposer, absorb, adapt, scavenger No (9)
13. Did you use the dictionaries to learn the meaning of a word that you did not know or were not sure about?	Yes (24) I was having a hard time remembering the definition of organism so it helped seeing the definition signed. No (13)
9a. How satisfied were you with the information available for each term? 9b. How satisfied were you with the accuracy of the signs? 9c) How satisfied were you with understanding the Avatar with the English text?	9a) Completely satisfied (25); Somewhat satisfied (11); Not satisfied (1) 9b) Completely satisfied (28); Somewhat satisfied (9) 9c) Completely satisfied (26); Somewhat satisfied (10); Not satisfied (1)

Key Findings

As described at the beginning of this report, the primary purpose of the field-test study was to begin to establish effectiveness of the dictionaries by investigating two research questions: 1-What kinds of learning gains in life science are possible with use of app versions of the SLSD? 2-What kinds of learning gains in physical science are possible with use of app versions of the SPSD? Our hypotheses were that with the apps, students will have assistive tools that helps them 1) increase their ability to recognize, sign/fingerspell and/or voice, and use the vocabulary of life and physical science; 2) improve their science content knowledge as reflected in their increased knowledge of the meaning of terms.

From the testing described in the Results section, it appears highly likely that the app versions of the SLSD and SPSD, when used as assistive tools, contribute to giving students in grades 9-12 who are deaf or hard of hearing access to science vocabulary in their own language. In so doing, they will likely be able to better understand the grade-appropriate science content that they are studying. Such access may also enable this population to work more independently to develop a technical life science and physical science vocabulary and may result in teachers having more time to focus on the teaching and learning of the topic content. Results also indicate that the apps' interactive features promote individualized instruction for a wide range of learners with varying levels of hearing loss and learning challenges. Teachers who used the app versions of the dictionaries were able to easily integrate them into their instruction. The Avatar technology also appears to motivate grade 7-12 students and fire up their curiosity and interest in learning science vocabulary.