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Signing High School Science

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Abstract

This paper discusses evaluation research conducted by TERC, Inc. in classrooms with students in grades 9–12 who are deaf or hard of hearing and who communicate in sign language. The primary purpose was to begin to establish effectiveness in terms of the kinds of learning gains that are possible with use of Web and app versions of a Signing Life Science Dictionary and a Signing Physical Science Dictionary. A secondary purpose was to find out about usability, use of the universally designed interactive features, and teachers' and students' satisfaction with the dictionaries as assistive tools for accessing science content. Developed by TERC and Vcom3D, each dictionary includes approximately 750 standards-based science terms, definitions, and illustrations; each is intended to enable increased access to life science and physical science content through individualized use. While results of this research reflect the experiences of students who used the dictionaries and do not include comparison with a group that did not use them, the data strongly support the assertion that the signing dictionaries provide the intended audience with assistive tools that add value to their learning experience when used during science classes.

Keywords

Deaf, hard of hearing, ASL, apps, computers, science.

Introduction

The evaluation research that is discussed in this paper was conducted by TERC, Inc. Its primary objective was to begin to establish effectiveness of Web and app versions of a Signing Life Science Dictionary (SLSD) and a Signing Physical Science Dictionary (SPSD). A secondary purpose was to find out about usability, use of the dictionaries and of the universally designed interactive features, and teachers' and students' satisfaction with the dictionaries as assistive tools for accessing science content. To accomplish our first objective, two questions guided our study: 1) What kinds of learning gains in life science are possible with use of the SLSD? 2) What kinds of learning gains are possible in physical science with use of the SPSP? Extrapolating from results of evaluation of our Signing Earth Science Dictionary (SESD), the research team hypothesized that with the SLSD and SPSP, students would 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 understanding of the meaning of terms (Vesel).

Based on recent estimates, there are roughly 76,600 children ages 3–18 with hearing impairments served under IDEA. Approximately 31,000, or 40%, are in grades 9–12 (U.S. Department of Education). Although students who are deaf or hard of hearing (HH) 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 (Rose and Meyer). This results in significant literacy limitations that lead to the majority of students who are deaf leaving high school with reading levels at the fifth grade or below. In fact, the English vocabulary of the average 15-year-old student who is deaf is about the size of that of a 9-year-old hearing child and will not improve significantly (Karchmer and Mitchell).

Developed by TERC and Vcom3D, each of the dictionaries is a complete assistive tool that contains approximately 750 standards-based science terms used in grades 9–12. Both dictionaries include signing avatars 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 et al.; Rose and Meyer). Integration of these interactive features was intended to offer deaf

and hard of hearing users in grades 9–12 increased access to standards-based life science and physical science content through individualized use of the dictionaries.

Discussion

Methods

With our research questions serving as the framework, we implemented a within-subjects mixed methods design that integrated qualitative and quantitative methods (Johnson, Onwuegbuzie, and Turner). This protocol, described below, resulted in a “full variety of evidence” (Yin) that was used for analysis.

The research procedure involved placing the dictionaries in the designated classroom context, at the intended grade levels, with students who are deaf or hard of hearing. The intent of the evaluation was to examine effectiveness under normal-use conditions. To this end, prior to using the dictionaries, teachers completed a *Site Data Form* that identified the science unit—one they would ordinarily cover—that they would teach using the SLSD or SPSD. The only difference was that they would teach the unit using at least one of the dictionaries. Teachers also identified 5 key terms that were important for developing an understanding of the content that was the focus of the unit. For example, one teacher identified *mitosis* as the unit topic; the key terms were *mitosis*, *cell cycle*, *chromosome*, *interphase*, and *replication*. (Each term selected had to be in the SLSD or SPSD.) The form also provided demographic information for each class. It included information about the school, teacher, and students and was used during analysis of the data.

Prior to starting the identified unit, each teacher completed a *Pre-use Vocabulary Assessment Form* to individually assess (as *yes* or *no*) students’ ability to recognize each of the 5 key terms and to sign/fingerspell and/or voice them. The teacher also assessed students’ ability to explain the meaning of each term and/or to define it using a 0–3 scale (0=no answer; 1=familiarity with the term but no knowledge of its meaning/definition; 2=incomplete knowledge of its meaning/definition; 3=complete ability to explain its meaning/definition). The teacher then taught the unit using the SLSD and/or SPSD as an assistive tool. A researcher conducted observations at sites local to TERC. Using an *Observation Log*, she made notes about how teachers incorporated the dictionaries into instruction and about student use.

After completing the unit, teachers used a *Post-use Vocabulary Assessment Form* to individually assess each student's ability to recognize the key terms, sign/fingerspell or voice them, and explain or define their meaning. Teachers and students also completed separate post-use surveys that supplied feedback about their experiences with the SLSD and/or SPSD.

Purposeful sampling (Patton) was employed to ensure that each class included students who: communicated using ASL; would be doing a unit that focused on standards-based life science or physical science content; could complete the unit within the testing timeframe; and had the requisite technology. This resulted in two cohorts of students using the Web-based dictionaries in different years. Cohort 1 included 5 classes and 28 students. Cohort 2 included 36 students and six classes. One cohort of 39 students from six classes tested the app versions during the same year as Cohort 2. Within each cohort, hearing-loss levels in the best ear without a cochlear implant or hearing aid ranged from mild to profound; signing levels ranged from survival to superior; English reading and writing levels ranged from below grade level to at grade level, with the majority of students below grade level.

To help us answer our research questions, we organized the results for pre/post-use vocabulary data into spreadsheets according to version (Web or app) and cohort. We further organized the data for each class within a cohort according to dictionary used (SLSD or SPSD), ability to recognize English text versions, ability to sign/fingerspell and/or voice terms, and ability to explain the meanings and/or definitions. These data were then analyzed as follows.

Pre/post-use data about students' knowledge of the five terms identified were tallied. Learning gains were expressed as the percentage change in ability to recognize English versions, sign/fingerspell and/or voice terms, and explain meanings and/or definitions. For example, for the ability to recognize English text versions of a term, for a class of 12, 60 correct responses were possible (5 terms x 12 students). If correct pre-responses for the ability to recognize English text versions of the term were 41, and post-responses were 52, students were able to recognize 41/60, or 68%, of the English versions of the term prior to using the dictionaries and 52/60, or 87%, after use. Therefore, this would represent a +19% gain in students' ability to recognize English versions of terms with use of the dictionary.

Survey data for each class were organized according to perceived gains in learning, usability, use, and satisfaction. Coding rubrics were generated to code comments from students and from teachers within each of the categories. Responses to Yes/No or Likert scale items were

tallied and sums calculated for the class, for each cohort, and for the 17 teachers and 80 students who completed and returned surveys. Coded responses were analyzed to detect trends in the data that would provide insight from teachers and students about our primary and secondary research objectives.

Results

Pre/post-use vocabulary assessment data showed the kinds of vocabulary and learning gains that are possible with use of the SLSD (Research Question 1) and SPSD (Research Question 2). With regard to the Web-based SLSD and SPSD, each class in Cohorts 1 and 2 improved in the class's ability to recognize the English text versions of the terms, sign/fingerspell or voice the terms, and explain the meaning of and/or define the terms. Pre/post-use data for the app version also showed improvement for each class in each of the three areas. One exception was a class whose members were able to sign/fingerspell all five terms prior to using the app version of the SPSD. Consequently this resulted in no improvement after using the dictionary. Overall, improvement with use of each version of the dictionaries was less for classes that demonstrated more ability at pre-assessment than for groups that demonstrated less ability.

Table 1. Learning Gains of Students Who Used Web-based Versions of the Dictionaries*

Dictionary	Cohort: Class	Number of Students	Recognize English Versions	Sign/Fingerspell and/or Voice Terms	Explain Meanings and/or Definitions
SLSD	I: 1	12	+30%	+52%	+67%
SLSD	I: 3	1	+100%	+100%	+80%
SLSD	I: 4	7	+46%	+63%	+43%
SLSD	I: 5	2	+50%	+90%	+43%
SLSD	II:3	3	+47%	+80%	+50%
SLSD	II:4	10	+90%	+90%	+70%
SLSD	II:5	8	+65%	+53%	+53%
SLSD	II:6	8	+35%	+53%	+40%
SPSD	I: 2	6	+40%	+67%	+77%
SPSD	II:1	1	+100%	+100%	+87%
SPSD	II:2	6	+80%	+43%	+70%

*Learning gains are expressed as the percentage change in the number of pre/post “yes” responses in ability to recognize English versions, sign/fingerspell and/or voice terms, and as the percentage change of pre/post 0–3 scores in ability to explain meanings and/or definitions.

Table 2. Learning Gains of Students Who Used App Versions of the Dictionaries*

Dictionary	Cohort: Class	Number of Students	Recognize English Versions	Sign/Fingerspell and/or Voice Terms	Explain Meanings and/or Definitions
SLSD	I: 3	9	+40%	+47%	+37%
SLSD	I: 6	1	+80%	+80%	+63%
SPSD	I: 2	5	+72%	+0%	+18.5%
SPSD	I: 5	2	+40%	+30%	+53%
SLSD & SPSD	I: 1	5	+20%	+16%	+17%
SLSD & SPSD	I: 4	17	+35%	+52%	+44%

*Learning gains are expressed as the percentage change in the number of pre/post “yes” responses in ability to recognize English versions, sign/fingerspell and/or voice terms, and as the percentage change of pre/post 0–3 scores in ability to explain meanings and/or definitions.

Responses in the post-use surveys, when students were asked to name a term and explain what they learned, provided additional insight into effectiveness of the dictionaries for learning new signs for terms and what the terms mean. While using the SLSD to study the topic of genetics and heredity, students reported learning the signs for and meanings of terms such as *nucleus*, *chromosome*, *spindle*, *recessive*, *chromatids*, and *replication*. While studying the topic of interactions among living things, they reported learning “an ecosystem has living and nonliving things.” They also reported never having known this before they used the SLSD. While using the SPSD to study the topic of solutions, students reported learning the signs for and meanings of terms such as *dissolve*, *solute*, *solvent*, *concentration*, and *solution*.

Evidence from students’ survey data also supplied information about usability and use. With regard to usability, most students found the SLSD and SPSD easy (45/80) or fairly easy (33/80) to use. With regard to use, students used the dictionaries during science activities and while doing homework to learn new signs (71/80) and to find out what terms mean (43/80). Their new vocabulary knowledge helped them understand written information (44/80) and discuss and explain content related to the topic of study (59/80). Observations made at sites within commuting distance of TERC supported these results from survey data.

With regard to use of the interactive features, more than half of the students reported viewing text in ASL (66/80), looking at illustrations (41/80), changing the signing speed (47/80), or selecting an avatar character (45/80). About 40% of the students zoomed in on an avatar character to see the signing (35/80), read the English (34/80), or view signed text. Students with sufficient hearing reported using the voice feature (20/80). Several students reported listening to terms and definitions voiced in Spanish and using the Signed Spanish feature (7/80).

Evidence from teachers’ survey data offered information about usability, use, and effectiveness. With regard to usability, teachers found the SLSD and SPSD easy (12/17) or fairly easy (5/17) to use. With regard to how they used the dictionaries, all teachers (17/17) reported using them to introduce vocabulary. They used the dictionaries with students to “preview material” that they would be studying. This made “the actual teaching of the content faster and smoother.” Teachers had students use the dictionaries to review key terms that were introduced previously as they encountered them during the unit. Most teachers used the dictionaries to supplement discussion (15/17) as well. They also had students use the SLSD and SPSD as

resources for looking up words they did not know as they encountered them while reading their textbooks, doing online research, or doing experiments.

With regard to effectiveness, teachers rated the dictionaries as either a very valuable (11/17) or a valuable (6/17) way to complement or enrich their instruction. They all indicated that the SLSD and SPSD could be used to accommodate different learning styles. “Students have a choice of how to get information and can work at their own speed.” “Changing the avatar’s appearance, zooming and rotating, and altering the signing speed helps to accommodate different students’ needs and preferences.” “For students who process information more slowly, I could change the speed of the avatar.” “For students who benefit from repetition, I could play the definition over and over.” “Students can work at their own speed to learn signs and what terms mean in their own language and in English and in Spanish.” “Listening to the definitions in English was good for students who are hard of hearing. The Spanish was good for one student.”

Also with regard to effectiveness, 100% (17/17) of teachers responded that the dictionaries enable communication, independence, and access to content. Their comments, as in the examples that follow, offer specifics: “Students have the vocabulary to describe the science they are learning.” “My students struggle to demonstrate their content knowledge, but the dictionary helps them try instead of just giving up.” “Students can access the material on their own. They no longer have to rely solely on the teacher to get vocabulary information.” “They can replay the signing avatar or re-read the definitions over and over to make meaning of the vocabulary on their own.” “The dictionaries give students an avenue for being more independent when trying to understand new concepts.”

Teachers’ and students’ post-use survey data provided insight into the degree to which they were satisfied with the dictionaries. All the teachers (100%) were completely satisfied with the information presented. Approximately three-quarters of the students (78%) were completely satisfied. The remaining 22% were somewhat satisfied. Approximately half of the teachers (53%) and more than three-quarters of the students (81%) were completely satisfied with the accuracy of the signs. More than three-quarters of the teachers (82%) and more than half of the students (54%) were completely satisfied with their understanding of what the avatar signed. The remaining 18% of teachers and 46% of students were somewhat satisfied.

Comments from teachers and students, as in the examples that follow, provided additional insight into their satisfaction with the dictionaries. Teachers wrote: “I like that this is a

resource all of my students can use, regardless of what level they are.” “They are great! We are using them for all of the science units during the year.” Students wrote: “It teaches me how to sign new words.” “I understand the meaning.” “I like going to all the dictionaries. I want to get the dictionaries for my home.” “I love it.”

Conclusions

While results of this research reflect the experiences of students who used the dictionaries and do not include comparison with a group that did not use them, it appears highly likely from the results presented that the SLSD and SPSD, when used as assistive tools, will contribute to giving students in grades 9–12 who are deaf or hard of hearing access to science vocabulary in their own language. Results suggest students will likely be better able to 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. Results also indicate that the dictionaries’ interactive features promote individualized instruction for a wide range of learners with varying levels of hearing loss and learning challenges. Teachers who used the SLSD and SPSD were able to easily integrate them into their instruction. In addition, the Avatar technology appears to motivate high school students and fire up their curiosity and interest in learning science vocabulary.

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