UNIVERSAL DESIGN in Higher Education
PROMISING PRACTICES

Increasing Access to Technical Science Vocabulary Through Use of Universally Designed Signing Dictionaries

Judy Vesel and Tara Robillard, TERC (Technical Education Research Centers), Inc.

BACKGROUND

State frameworks and national standards are explicit about the science and mathematics content that students in grades K-12 must master at each grade level. The Individuals with Disabilities Education Act (IDEA) and the No Child Left Behind (NCLB) Act mandate that students in grades K-12 who are deaf or hard of hearing must have access to this content.

Although individuals who are deaf or hard of hearing are not necessarily considered "print disabled," those who acquire and use American Sign Language (ASL) to communicate tend to internalize a linguistic structure that differs greatly from English. This makes using English similar to working in a foreign language. It also results in significant limitations in English-language literacy that lead to the majority of deaf students leaving high school with reading levels at the fifth grade or below. In fact, the English vocabulary of the average 15-year-old deaf student is about the size of that of a 9-year-old hearing child and will not improve significantly (Karchmer & Mitchell, 2006). Consequently, students who are deaf or hard of hearing often miss many of the age-appropriate science and math learning experiences that provide the foundations for developing the understanding necessary for studying and/or majoring in STEM areas after leaving high school. This may contribute to the small proportion of deaf and hard of hearing people in STEM careers (0.13–0.19%) compared to the general population (11–15.3%) (National Center for Science and Engineering Statistics [NCSES] 1996, 2004, 2009, 2011).

As a response to this situation, TERC, an educational research and development organization, and Vcom3D, developers of SigningAvatar® assistive software, have been collaborating for more than a decade in research and development of universally designed signing dictionaries. Each dictionary contains a minimum of 750 content-specific core-based terms and definitions, most of which include an illustration or example, and utilizes virtual characters—avatars—that sign. Windows-based Web versions and the plug-in are available free at http://signsci.terc.edu/. Apps are available through the Apple App Store on iTunes.

This article focuses on the science dictionaries for grades 9-12—Signing Earth Science Dictionary (SESD), Signing Life Science Dictionary (SLSD), and Signing Physical Science Dictionary (SPSD). We first describe the rationale supporting Universal Design for Learning (UDL) as the approach used for the dictionaries. We then provide evidence of impact of dictionary use in schools. Finally, we suggest possibilities for use in postsecondary settings.

RATIONALE FOR UDL AS THE APPROACH USED FOR THE DICTIONARIES

UDL offers users multiple options, flexibility, and choice. Other salient features are an emphasis on cognitive access and social inclusion. Universal design strives to create experiences that are accessible to learners along a broad spectrum of abilities and disabilities by offering them a choice of options. Its three principles are that instructional materials should provide 1) multiple means of representation; 2) multiple means of action and expression; and 3) multiple means of engagement (Rose & Meyer 2006).

UDL was selected as the approach used for the dictionaries because it enabled the partners to avoid the pitfalls of a one-size-fits-all solution. Instead, multiple options could be offered to an audience with a broad spectrum of abilities and communication needs. For example, levels of hearing loss, language of communication, and science knowledge among the learners for which the dictionaries are intended vary greatly. This variability necessitates a range of methods available for acquiring knowledge and for communicating with hearing and non-hearing teachers and peers. Table 1 shows how each of the three principles of UDL have been integrated into the dictionaries to provide an array of choices that accommodate differences among learners who are deaf or hard of hearing.

Table 1: UDL Principles, Differences Accommodated, and Dictionary Choices

UDL Principle	Differences Accomodated	Dictionary Choices
I: Provide Multiple Means of Representation	Ways deaf or hard of hearing learners approach content to acquire information	Selection of terms and definitions as text, human voice narration, signing, illustrations/examples*
II: Provide Multiple Means of Action and Expression	Ways deaf or hard of hearing learners explain their science thinking and demonstrate what they know	Use of ASL, Word-for-Word translations (SE or SS for Spanish), illustrations, voiced text
III: Provide Multiple Means of Engagement	Ways deaf or hard of hearing learners can be engaged or motivated to learn	Selection from a group of avatars of different ages, ethnicities, and genders; Ability to change the signing speed and text size.

* Available in English for the SESD and in English and Spanish for the SLSD and SPSD

EVIDENCE OF IMPACT OF DICTIONARY USE

A mixed-measurement pre/post design that results in qualitative and quantitative data was used to begin to ascertain the types of vocabulary-learning gains that are possible with the dictionaries. This approach

enabled the partners to examine effectiveness of the interventions in classroom settings under real conditions when used by students who vary greatly in aspects such as hearing-loss level, language use, science knowledge and skills, and reading ability. Although the dictionaries were developed for grades 9-12, they include a set of terms (designated as Level 1) that students should encounter in the middle grades before entering high school. Therefore, the research design also sought to find out about the learning gains of this younger group of users.

Participants were drawn from a pool of teachers who taught at schools for the deaf and had worked with TERC previously. They were also recruited via TERC's and Vcom3D's websites and from newsgroups such as EDUDEAF. Teachers were selected based on grade level, number of students in their class(es), and science content area. The intent was to examine effectiveness under normal-use conditions. To this end, each teacher selected one science unit from their normal teaching sequence to do using the dictionary as an assistive tool. Each teacher also identified 5 to 10 terms from the signing dictionary that were important for developing understanding of the content that was the focus of the unit. Using a vocabulary assessment form, teachers assessed as yes or no each student's pre- and post-unit ability to recognize the English text version of the term; sign, fingerspell, and/or voice the term; and use it in a sentence. Using a 0-3 point scale (where 0=no answer and 3=a complete and accurate explanation), teachers also assessed students' ability to understand or give the meaning of the term. Employing post-use surveys, teachers and students provided feedback about ease of use of the dictionaries and likes and dislikes. Key findings (Vesel 2011, 2012; Vesel & Robillard 2014) from these studies are summarized below. Additional information is available at *signsci.terc.edu*.

Table 2: SLSD & SPSD Users' Mean Pre/Post Change in Vocabulary Knowledge

Group	N	Dictionary	Recognize English Version	Sign/Fingerspell/ Voice	Use in a Sentence	Provide Meaning or a Definition
1	12	SLSD	+30%	+52%	+58%	+67%
2	6	SPSD	+40%	+67%	+10%	+77%
3	1	SLSD	+100	+100%	+100%	+80%
4	7	SLSD	+46%	+63%	+49%	+43%
5	2	SLSD	+50%	+90%	+30%	+43%
6	1	SPSD	+100%	+100%	+60%	+87%
7	6	SPSD	+80%	+43%	+77%	+70%
8	3	SLSD	+47%	+80%	+33%	+50%
9	10	SLSD	+90%	+90%	+8%	+70%
10	8	SLSD	+65%	+53%	+38%	+53%
11	8	SLSD	+35%	+53%	+48%	+40%

Table 3: SESD Users' Mean Pre/Post Change in Vocabulary Knowledge*

Group	N	Sign/Fingerspell/ Voice Term	Use Terms in a Sentence	Understand the Meaning of Terms	Use in a Sentence	Provide Meaning or a Definition
1	3	+74%	+53%	+60%	+58%	+67%
2	8	+46%	+44%	+54%	+10%	+77%
3	6	+37%	+49%	+45%	+100%	+80%
4	9	+49%	+49%	+44%	+49%	+43%
5	15	+15%	+22%	+30%	+30%	+43%
6	9	+37%	+51%	+48%	+60%	+87%
7	6	+61%	+70%	+23%	+77%	+70%

*SESD testing did not include recognition of the English version of the term.

Based on these results, it appears highly likely that, when used as assistive tools, the dictionaries will contribute to giving students who are deaf or hard of hearing access to science vocabulary in their own language. Qualitative survey data indicate that such access may enable this population to work more independently to develop technical earth and space, life, and physical science vocabularies and also may result in teachers having more time to focus on the teaching and learning of the topic content. Findings 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 dictionaries found them to be a welcome source of standardized signs for technical terms—they no longer had to spend time making up signs or fingerspelling terms. The dictionaries served to standardize signs used throughout a school and for interpreters who lacked a foundation in STEM to use in mainstream settings and when working individually with students (Vesel, 2011, 2012; Vesel & Robillard 2014).

POSSIBILITIES FOR DICTIONARY USE IN POSTSECONDARY SETTINGS

Accessibility to spoken English—the mainstream language used for communication in postsecondary STEM lecture and lab settings—can be subpar for the target audience (Marschark et. al. 2005). In these instances, real-time captioning (often made available through Communication Access Real-time Translation [CART]) is not always suitable, and an ASL interpreter becomes necessary (Wald 2006). However, interpreters at the postsecondary level, like those in pre-college settings, often have insufficient training in STEM and are unaware of appropriate technical signs to use for communication of accurate information in ASL. This can result in instructors having to prepare interpreters who will be translating for their undergraduate students. Interpreters must be introduced to the key vocabulary terms in ASL that they might encounter as spoken English during lectures and lab sessions. Deaf and hard of hearing graduate students would have the task of preparing their own interpreters. This is a time-consuming undertaking and some-

thing that does not apply for hearing students. An additional complication is that different interpreters may be assigned to different classrooms weekly.

Still, the time that is spent on preparing interpreters appears to be necessary if students who are deaf or hard of hearing and who require information to be presented in ASL are to receive equal access to the same amount and quality of information as their hearing peers (Solomon, Graham, Marchut, & Painter 2013). Prior to the recent emergence of resources such as the signing dictionaries, it had been difficult for those preparing interpreters to locate standardized signs for scientific terminology. Given this situation, and supported by our work in high school settings, it appears that use of the terms in the dictionaries might represent a powerful resource. Instructors and graduate students could use the dictionaries to introduce interpreters in person to the signs and meanings of many of the basic terms they need to know. Alternatively, or in addition, they could supply interpreters with lists of terms from the dictionaries that they are likely to encounter. When used in these ways, the SLSD, SPSD, and SESD could be valuable and effective time-saving resources for preparing interpreters to communicate STEM course material. As such, they might provide a new opportunity for helping postsecondary students receive more equal access to information.

REFERENCES

Karchmer, M., & Mitchell, R.E. (2006). Demographic and achievement characteristics of deaf and hard-of-hearing students. In M. Marschark & P.E. Spencer (Eds.), *Oxford handbook of deaf studies, language and education* (pp. 21–37). New York, NY: Oxford University Press.

Marschark, M., Pelz, J., Convertino, C., Sapere, P., Arndt, M., & Seewagen, R. (2005). Classroom interpreting and visual information processing in mainstream education for deaf students: Live or Memorex? *American Educational Research Journal, 42*(2), 727–761.

National Center for Science and Engineering Statistics [NCES]. (1996, 2004, 2009, 2011). Women, minorities and persons with disabilities in science and engineering (NSF Publication No. 96-311, No. 04-317, No. 09-305, 11-309). Retrieved from *www.nsf.gov/statistics/women/.*

Rose, D., & Meyer, A. (2006). *A practical reader in universal design for learning*. Cambridge, MA: Harvard Education Press.

Solomon, C., Graham, S., Marchut, A. & Painter, R. (2013). Where are the leaks for deaf and hard-of-hearing people in the science, technology, engineering, and mathematics (STEM) pipeline? Paper presented at the annual meeting of the American Educational Research Association. Retrieved November 10, 2013 from the AERA Online Paper Repository.

Vesel, J. (2011). Breaking barriers. International Innovation-North America. December 2011, 122–124.

Vesel, J. (2012). *Signing earth science dictionary: Field test evaluation report*. Retrieved from *signsci.terc.edu/publications/index.html*

Vesel, J., & Robillard, T. (2014). *Signing high school science: Field test evaluation report*. Retrieved from *signsci.terc.edu/publications/index.html*

Wald, M. (2006). Creating accessible educational multimedia through editing automatic speech recognition captioning in real time. *Interactive Technology and Smart Education, 3*(2), 131–141.

ACKNOWLEDGMENTS

The Signing Earth Science Dictionary was funded under National Science Foundation Award #GEO-0913675. The Signing Life Science Dictionary and Signing Physical Science Dictionary were funded under National Science Foundation Award #DRL-1019542. This article is part of the collection Universal Design in Higher Education: Promising Practices, sponsored by the DO-IT Center.

REFERENCE FORMAT FOR THIS CONTENT

Vesel, J., & Robillard, T. (2014). Increasing access to technical science vocabulary through use of universally designed signing dictionaries. In S. Burgstahler (Ed.), Universal design in higher education: Promising practices. Seattle: DO-IT, University of Washington. Retrieved from *www.uw.edu/doit/increasing-access-technical-science-vocabulary-through-use-universally-designed-signing-dictionaries*