

Breaking barriers

SESD

Principal Investigator **Ms Judy Vesel** explains how an illustrated and interactive 3D dictionary – developed by a TERC research group using SigningAvatar® technology – is enabling deaf and hard of hearing high school students to take command of complex Earth Science terms and definitions

To begin, could you explain your project's objectives?

The goals of the project are to:

- Research, develop, and disseminate an illustrated interactive 3D dictionary of standards-based Earth Science terms and definitions for high school students who are deaf and hard of hearing and whose first language is sign
- Evaluate the extent to which use of the Signing Earth Science Dictionary (SESD) furthers understanding of standards-based Earth Science content, command of the language of Earth Science, and the ability to study Earth Science independently
- Build a robust avatar lexicon of signed Earth Science terms that developers, educators, and professionals can use when generating signed Earth Science materials

Can you outline some of the ways the Signing Earth Science Dictionary (SESD) improves upon traditional Earth Science education programmes? How does your

approach address these problem areas?

The SESD includes 750 key Earth Science terms and is the first tool of its kind to bring high school Earth Science learning to life using characters that sign. It is powered by Vcom3D's SigningAvatar® technology and incorporates interactive features that support Universal Design for Learning. As such, it provides members of the target population with the language support they need to access Earth Science content delivered on the web, via electronic media, in hard copy and in conversation.

How have you applied the technology and thinking behind the SESD to other subject areas? Were any special modifications required to adapt the dictionary to the different subject matters?

The rationale for the SESD is based on a disciplinary and conceptual research base. A component of the conceptual research base uses the partners' prior research and development of their Signing Science Dictionary (SSD) for 9-14 year olds as evidence of the potential effectiveness of the SESD. Although

the SSD was developed for younger students, comparison of the pre- and post-use scores for 14-16 year old students who also used the dictionary showed significant improvement in vocabulary and content knowledge and in the ability to engage independently in learning and communication of scientific ideas.

The SESD belongs to a body of work referred to as Signing Math and Science that includes a Signing Math Pictionary for ages 5-9 and the SSD. For these, and all of the dictionaries, research and development includes: identifying the terms to be included; developing the parts of speech and definitions; scripting the text components in American Sign Language (ASL) and Signed English (SE); identifying and developing illustrations; refining the interface and integrating the terms; and conducting an evaluation for usability and effectiveness.

How was the SigningAvatar® technology developed and what makes it unique in its concept?

Vcom3D has researched and developed the SigningAvatar® animation technology that



Signing science

provides sign language access to digital media using 3D animated characters known as avatars. This technology is used for the SESD. Because it runs in an Internet browser or as stand-alone software, SigningAvatar® content can be embedded in web pages or stored on an Internet server or CD-ROM. Designed for use with Windows and Vista operating systems, it has been developed using cross-platform Java, XML, and Extensible 3D (X3D) standards to maximise portability across multiple platforms.

In the underlying SigningAvatar® technology, each sign is stored as motions of body joints as a function of time in a reusable library of animations that can be assembled, using Vcom3D's Sign Smith™ Studio Authoring Tool, to create new passages. The signs in this library are made using standard desktop animation software. This Sign Smith™ Studio Authoring Tool also allows each sign to be 'inflected' to indicate spatial references, classifiers, role shifting, emphasis, time, and other elements of ASL grammar. Facial expressions are stored in a library that can be accessed by the Authoring Tool, so that grammatical ASL and SE passages can be created using only the desktop software. Working with the Authoring Tool, an interpreter develops low-bandwidth, easily edited 'scripts' that tell the Avatar what to sign. The signed translation of 100 pages of text can be stored on a single floppy disk (1.4 MB), or downloaded in minutes. Signs animated for one Avatar character can be readily applied to other characters.



The specialised lexicon associated with Earth Science studies is presently prohibitive to advanced comprehension by deaf and hard of hearing learners. The development and dissemination of an innovative **Signing Earth Science Dictionary** is set to revolutionise and standardise the way Earth Science is taught to these students in U.S. high schools

THE MANY BRANCHES and facets of science enable us as individuals to comprehend, act on, and contribute to the challenges that affect society. In recognition of this fact, the National Science Education Standards (NSES) present a clear vision of what U.S. students are expected to achieve in science at all grade levels. This vision must obviously extend to students with disabilities, especially when understood in combination with equal rights legislature such as the Individuals with Disabilities Education Act (IDEA) and No Child Left Behind Act of 2001 (NCLB). However, there is a stark contrast between the framework and the actual standard of Earth Science education for disabled youths in the U.S. For the (approximate) 36,000 14-17 year-old students who are deaf or hard of hearing in the U.S. there are no known dictionaries of terms and definitions that focus on geoscience and use sign as a language of communication.

Aiming to realign Earth Science studies with the objectives of the NSES, NCLB and IDEA, steps have been taken by a research team at TERC to engage, inspire and expand opportunities for high school geoscience students who are deaf or hard of hearing. TERC is an independent, research and development organisation involved in creating a unique learning tool as part of their 'Signing Math & Science' initiative. Led by Ms Judy Vesel, in collaboration with Vcom3D, developers of the SigningAvatar® technology, and funded by the National Science Foundation (NSF), the project team are working on a Signing Earth Science Dictionary (SESD). This illustrated and interactive 3D learning instrument is a response to the needs of teachers, students and the geosciences community, and will be used by high school students as an assistive research-based tool to study complex Earth Science content.

THE SESD

The SESD has emerged from previous research and development conducted by TERC and Vcom3D with funding from NSF and the U.S. Department of Education. The Signing Science Dictionary (SSD) was designed for younger students aged between 9-14 and – much like the objectives of the SESD – is aimed at improving their vocabulary and technical knowledge using SigningAvatar® technology. When the SSD underwent a rigorous testing

phase it received high praise from students and teachers alike; it was recognised as a tool with the ability to independently engage students in learning and communication of scientific ideas, and did so in a novel and creative way. This was shown by a marked increase in students' knowledge of science terms and related content from the beginning to the end of the test period. The SSD was received so well, in fact, the users involved in the research phase expressed the need for a more advanced version of it: "Teachers recognised the SSD as a tool that they could easily incorporate into teaching and use to improve their own visual vocabulary. Students reported that the SSD made it easy for them to understand. In the context of their overwhelmingly positive experience, they articulated the need for a high-school specific version of the SSD," Vesel highlights. The SESD was thus conceived.

Teachers recognise the SSD as a tool that they could easily incorporate into teaching

There are approximately 750 key terms and definitions specifically for Earth Science included in the SESD. All are communicated through American Sign Language (ASL) and Word-for-Word translation (Signed English, SE), with fingerspell incorporated as appropriate. By collating this content and disseminating it in

an accessible and unique way, the project is adhering to the three principles of Universal Design for Learning (UDL). The UDL principles are to provide access to information in a variety of ways, incorporate multiple methods for users to express their acquired knowledge, and provide a series of solutions to ensure users are challenged, motivated and engaged. Vesel outlines how these three principles are embedded into the SESD: "Students are able to access a geoscience term by typing it into a search box or scrolling down a letter-list page, view a part of speech, illustration, entire text block, or individual words on a page in any order and as often as they like," she explains. Moreover, students can choose the gender and ethnicity of their avatar and the dictionaries will be disseminated via the web and as a CD-ROM and an app.

The project team opted for a classroom-based research approach to ensure the SESD technology is user-friendly for both students and teachers and to document its effectiveness as a teaching and learning tool. Spanning a period of approximately seven months, they utilised a

INTELLIGENCE

SESD

THE SIGNING EARTH SCIENCE DICTIONARY FOR GRADES 9-12 TRACK 1 PROJECT

OBJECTIVES

To research and develop an illustrated interactive 3D dictionary of standards-based Earth Science terms for high school students who are deaf and hard of hearing and whose first language is sign using Signing Avatar® assistive technology. To establish the effectiveness of the dictionary, project staff are investigating the kinds of learning gains that are possible when it is used.

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JUDY VESEL holds degrees in Biology, Linguistics, and Education. She was the Principal Investigator for the Leveraging Learning and Science for Today and Tomorrow projects (funded by NSF). She is also the Principal Investigator for 'Signing Math & Science' (<http://signsci.test.terc.edu/>). Her experience as an educator extends from the primary grades through high school.

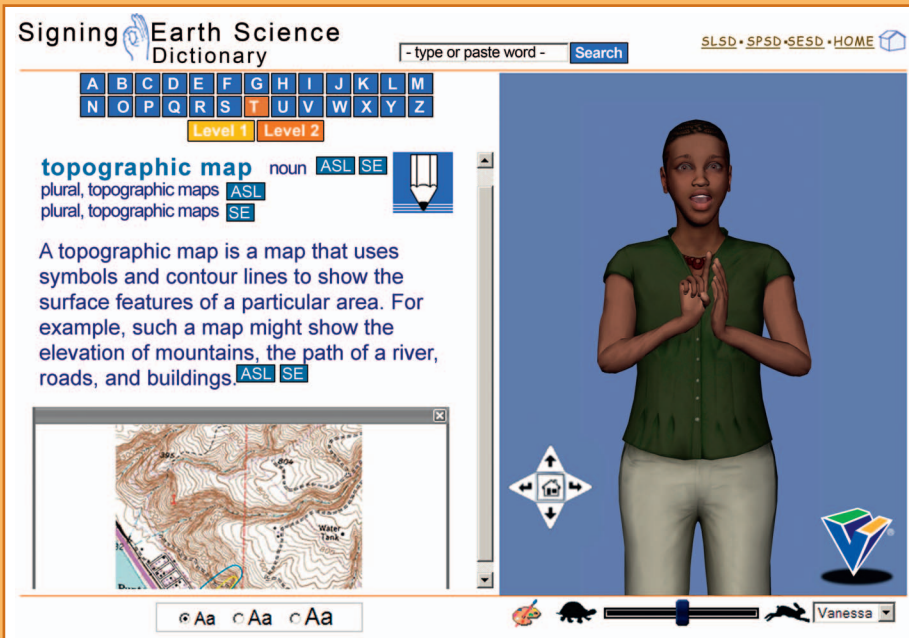


FIGURE 1. A page from the SESD and the interactive UDL features that have been incorporated into the interface.

mixed measurement pre/post research design with three phases, building on the methodology used for development of their other 3D interactive signing dictionaries. The first phase included administering a pre-unit vocabulary/content questionnaire to students to garner a baseline assessment of their initial knowledge of key Earth Science terms. The second phase involved students using the SESD under normal classroom conditions to complete a regular unit of the Earth Science curriculum. The third phase involved administering a questionnaire identical to the pre-unit assessment to ascertain changes in their vocabulary/content knowledge with use of the SESD. This was augmented with the collection of survey data that included teachers' and students' comments about usability of the technology and about their experiences.

BUILDING MODERN SKILLS

The SESD affords students independence in their studies – indeed, it was this aspect which stood out as the most beneficial of the dictionary. Such a learning tool brings with it a wealth of fundamental vocabulary and embedded information that provides deaf or hard of hearing students the opportunity to connect

with Earth Science materials outside of class. It enables them to do homework, complete projects independently, and discuss what they are learning with peers, family and experts: "Teachers particularly liked having a tool that 'standardises' the language they use with their students and that they can use to improve their own technical vocabulary," explains Vesel. Such independence brings with it a unique opportunity to engage students who are deaf or hard of hearing in experiences that build modern skills of inquiry, exploration and discovery in Earth Science and, in particular, in geoscience. It may also inspire the students who use it to pursue scholarships and forge careers in a field that has been previously inaccessible to them.

The next step for the TERC research team is to incorporate feedback into the design of the SESD before publication via the web, CD-ROM and mobile devices. The feedback will also be incorporated into the development of the project team's other signing dictionaries, including a Signing Life Science Dictionary and Signing Physical Science Dictionary for 14-18 year old students. These dictionaries will all have a mirror dictionary in Spanish and include human narration of all text-based elements.

