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Abstract

Interpreters who are skilled in academic ASL content, such as the vocabulary needed to interpret postsecondary science courses, are rare. This is not surprising, because interpreting training programs focus on developing the skills to fluently interpret from sign to voice as well as voice to sign, not on the specialized vocabulary for more specialized content. This study examined the impact of training interpreting students on the use of a Signing Bioscience Dictionary (SBD). Research involved incorporating terms found in undergraduate biology courses into the SBD, conducting an evaluation, and soliciting recommendations for improvement of the SBD. Key findings showed that using the SBD to teach life science terms resulted in students' increased knowledge of ASL life science vocabulary and abilities to sign these terms. These skills transferred to interpreting skills for a life science lecture only in those students who were more advanced in the program.

Keywords: interpreter education, science interpreting, ASL science vocabulary, dictionary

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1. Introduction and background

Research focusing on inclusion of deaf and hard of hearing students in science learning experiences was characterized more than a decade ago as scant (Stinson & Kluwin, 2003). To date, there are many major gaps that exist (Moon, Todd, Morton, & Ivey, 2012), and the knowledge base continues to be in need of expansion (Gormally & Marchut, 2017). Research shows that one of the educational barriers that deaf and hard of hearing students face, particularly at the postsecondary level, is that they often do not have access to a full range of accommodations, including access to sign language interpreters that facilitate communication and promote inclusion (Powell, Hyde, & Punch, 2014).

This article describes a study that focuses on a Signing Bioscience Dictionary (SBD), which presents life science terms and their definitions in ASL as well as in written and spoken English. We explore the effectiveness of the SBD when used in conjunction with Lamar University's interpreting program, specifically, the degree to which use of the dictionary increases student interpreters' ASL life science vocabulary and content knowledge and ability to interpret material fluently and accurately.

2. Literature review

2.1. Research as it relates to availability and training of interpreters of science material

Although language proficiency is a prerequisite for interpreting, it is no guarantee of interpreting skill (Dean & Pollard, 2001; Finton, 1998; Frishberg, 1986; Napier, 2002), and in fact "interpretation, like translation, involves a multi-dimensional competency that is hard to define and to teach, and even harder to evaluate" (Roberts 1992, p. 16). It is apparent from the literature that many and varied skills, a broad knowledge base, general cognitive ability, vocational aptitude, and attitude all contribute to interpreter competence, and, therefore, to interpreter performance (Bontempo & Napier, 2007). The key skills, knowledge, and abilities that can be drawn from the literature and applied to sign language interpreters result in an extremely long list. Among these are "sign language skills; spoken language skills; interpreting/translating skills; a sense of ethical responsibility and integrity; cultural sensitivity; interpersonal skills; willingness to learn; self-discipline; trustworthiness; professionalism; flexibility; and a sense of humor, among many more specific components for competent practice" (Bontempo & Napier, 2007, p. 277; see also Frishberg, 1986; Napier, 2002; Solow, 1981).

Creating programs that accomplish the above list of skills is not an easy feat. Currently, there are 2-year associate degree programs in ASL interpreting as well as 4-year BA degree programs (Landa, 2018; Landa & Clark, 2018, 2019) with more graduate programs emerging. Accreditation agencies are moving toward eliminating certification for AA degrees (Landa, 2018), and many students now transfer to 4-year programs at the end of their AA program (Z. Smith, personal communication, August 2020). Research (Smith & Maroney, 2018) has shown that interpreter education has primarily focused on ASL acquisition and competence and neglects development of the whole interpreter as it relates to the professional practice of interpreting. It is important to note that most interpreter training programs accept students with little to no sign language skills. However, entry-level skill is critical in the development of interpreters' skills because skills in social language require 2 to 4 years to develop, whereas academic language skills require 7 years to become well developed (Cummins, 2008). Therefore, many interpreting graduates have not developed academic level skills in sign language and learn these skills later, on the job. Moreover, the curriculum used in interpreting training requires little to no science background (Cooke & Graham, 2012; Graham, Solomon, Marchut, Kushalnagar, & Painter, 2012). Results from a study that used the Educational Interpreters Performance Assessment (EIPA), an evaluation instrument used to assess and certify K-12 classroom interpreters, to evaluate approximately 2,100 educational interpreters from across the United States showed that approximately 60% of the interpreters had inadequate skills to provide full access to the general curriculum (Schick, Williams, & Kupermintz, 2006). This lack of skilled interpreters at the primary grades is compounded at the postsecondary level, especially in STEM fields.

Given the lack of postsecondary science programs that are delivered in ASL, and the availability of only one science PhD program that uses direct communication in sign—the Program in Educational Neuroscience, Gallaudet University—for many sign language users who are deaf, the only way to achieve productive communication of STEM content is through the use of qualified sign language interpreters who are able to interpret effectively and accurately using the necessary specialized vocabulary (Americans With Disabilities Act, 2014). However, research (Gormally, 2017; Kurz, Schick, & Hauser, 2015) shows that students in science courses frequently receive content translation from interpreters who are unfamiliar with concepts or do not have a command of the necessary specialized vocabulary and content needed for accurate interpretations. Those interpreters who are available may fail to make the scientific language "visible" or comprehensible and may rely heavily on citation fingerspelling and word-for-word transliteration, thereby rendering science course content minimally accessible (Seal, Wynn, & MacDonald, 2002). This puts many students who are deaf or hard of hearing at a disadvantage when it comes to STEM learning and can result in discouraging them from pursuing science degrees.

2.2. Research as it relates to the characteristics and availability of STEM ASL lexicons

Complicating the scarcity of interpreters with STEM knowledge is the lack of a common ASL lexicon for scientific terms (Lang et al., 2007). In recent years, several online databases with ASL signs for technical scientific terms and concepts have become available. Among these are several math and science lexicons that feature searchable collections of a small number of basic STEM terms presented as videos of terms and signs. These are available online and include the Rochester Institute of Technology's /National Technical Institute for the Deaf (RIT/NTID) math and science lexicons (Rochester Institute of Technology, n. d.); ASL STEM forum (University of Washington, n. d.); DEAFSTEM (DEAFSTEM, n. d.); and the Texas Math Sign Language Dictionary (Texas School for the Deaf, n. d.), and the Signing Math & Science Dictionaries.

The Signing Math & Science Dictionaries (Signing Math & Science, n.d.) are a series of grade-level and content-specific standards-based sign language dictionaries that were developed by TERC (an educational research and development organization) and Vcom3D (developers of SigningAvatar assistive technology). The dictionaries for Grades 9-12 focus on different areas of science content — life, physical, Earth, and space science. Although the dictionaries were originally intended for student use, researchers soon discovered that teachers were using them before teaching a unit to check the accuracy of the signs they use and to learn signs for terms they did not know (Vesel, 2014, 2015). An unexpected finding was that many of the terms incorporated into the Signing Life Science Dictionary (SLSD), one of the dictionaries in the series for grades 9-12, are also used in undergraduate biology courses (Vesel & Robillard, 2014). For these reasons, and because interpreters are often called upon to interpret material that includes life science terms with high levels of technical vocabulary (Garberoglio, Cawthon, & Sales,

2017; Madhusoodanan, 2016), biology was selected as the focus and source of terms for the SBD that was used for the study and is discussed in this paper.

The SLSD comprises approximately 1,000 terms students most frequently encounter when studying life science. Identification of terms and development of English text definitions was led by the lead author of this article. This involved collaboration with a range of scientists and classroom educators who were hearing, hard of hearing, and deaf. Creation of signs was led by Jason Hurdich one of the two primary investigators (hereafter "co-PI") from Vcom3D who is deaf, holds an MEd in Sign Language Interpretation, and is a Registry of Interpreters for the Deaf (RID) Certified Deaf Interpreter and a university lecturer of ASL. Because signs for many of the terms in the dictionary do not exist, they had to be created. To create them, the co-PI worked with scientists from Gallaudet University and RIT/ NTID who were also deaf, as well as science educators at schools for the deaf. The process of sign development involved identifying signs for terms that are in usage in different parts of the country and overall. In cases where different signs for the same term were used, the sign selected for the SBD was based on the sign that specialists in the field determined conveyed the most accurate scientific meaning of the term. (Many signs in the SBD incorporate fingerspelling because the consensus was that use of fingerspelling or a combination of sign and fingerspelling was the best way to convey the scientific meaning of a term.) Each SBD term incorporates a Signing Avatar that signs on demand the English-text version of the term and its definition. In most cases, an illustration is provided. The three principles of universal design for learning (Rose & Mayer, 2006) are incorporated to avoid a "one size fits all" approach. Terms and definitions are represented as static images, text, human narration, and signing to give learners various ways of acquiring knowledge. Users can select ASL, English text, illustrations, or voiced text. Results of field test evaluations show that the SLSD serves as a communication bridge that makes science more accessible (Vesel, 2014; Vesel & Robillard, 2014).

2.3. Contribution of the study to the existing research base

Research shows that supporting the undergraduate science education of the next generation of students who are deaf or hard of hearing will require increasing the pool of interpreters who can convey science content (Cooke & Graham, 2012; Witter-Merithew & Nicodemus, 2011). To accomplish this, one of the resources interpreters need is knowledge of a signed STEM vocabulary (Grooms, 2015; Lang et al., 2007; Solomon, Graham, Marchut, & Painter, 2013) and of the STEM content they will be called on to interpret (Gormally, 2017; Kurz et al., 2015). The study that follows focused on the acquisition of life science vocabulary knowledge and content. Results provide new information about use and effectiveness of a Signing Bioscience Dictionary specifically designed to help interpreting students at Lamar University build a robust life science vocabulary and knowledge of the content they are interpreting. These new understandings provide new information about the effectiveness of the SBD in strengthening Lamar's undergraduate interpreters' STEM ASL vocabulary and knowledge, to better prepare them to interpret in undergraduate life science content. Use of the SBD in other interpreting training programs is likely to be similarly effective.

3. Method

To study use of the SBD, researchers investigated four research questions:

1. How do undergraduate interpreting students use the SBD to learn life science terms?
2. How effective is the SBD in increasing undergraduate interpreting students' knowledge of the vocabulary and their ability to sign life science terms?
3. How effective is the SBD in increasing undergraduate interpreting students' capacity to accurately and clearly interpret content typically taught in undergraduate biology courses?
4. What additions and/or changes would make the SBD more effective?

To answer these questions, the team first prepared the SBD (see Section 3.1 below). We then evaluated the use and potential effectiveness of the SBD in supporting undergraduate students in Lamar's interpreting program to

develop an ASL life science vocabulary and use it to interpret content taught in undergraduate biology courses (see Sections 3.2 & 4.1-4.3 below). Last, we identified terms to include in an expanded version of the SBD and solicited recommendations for improvement from participating students and interpreting instructors (see Section 4.4 below). The demographics of the undergraduate ASL interpreting student participants is shown in Table 1.

Table 1: Demographics of study participants (N = 26).

Ethnicity	
White	12
Latinx	10
Black	4
Gender	
Female	26
Male	0
Year in program[a]	
First	4
Second	8
Third	11
Fourth	2
ASL proficiency[a]	
Level 1	4
Level 2	1
Level 3	5
Level 4	6
Level 5	6
Level 6	3

[a] Data missing for one student.

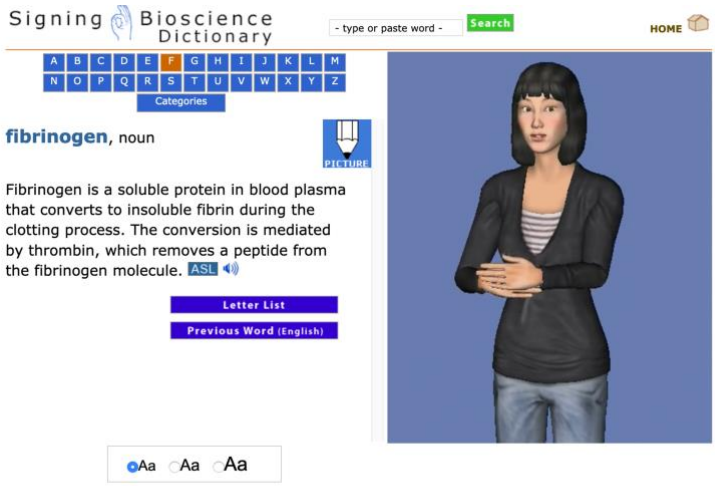
3.1. Procedure for development of the SBD

The Lamar University SBD development team included a lead researcher and assistant professor in the Department of Deaf Studies and Deaf Education who is deaf and uses ASL as her preferred method of communication; and several research assistants who are deaf. The team developed the SBD during the first year of the project, beginning by reviewing the glossary entries in *Campbell Biology*, 8th ed. (Reece & Campbell, 2008), to identify an initial set of terms. This text was selected because it is used in undergraduate biology courses at the university. The review resulted in a list of terms that was submitted to the TERC Research and Development (R & D) team with the terms organized by text chapter. The R & D team then identified those terms that are included in at least one of the signing dictionaries for Grades 9-12. They also identified additional terms that were not in the university list and are necessary for fully understanding the meaning of a dictionary term or content directly related to a term. This resulted in a final list of 1,580 terms to incorporate into the SBD.

The university team then used the *Campbell Biology* chapter headings to create content categories for the terms from the text that had been incorporated into the final list. Review of the additional terms drawn from the signing

dictionaries with respect to their fit with a category resulted in the R & D team creating a modified set of categories that included most of the terms identified for inclusion in the SBD. It also resulted in a set of terms that did not clearly fit into a category and would appear in the letter list only. The final list of 12 categories that emerged was as follows: Animal Structure & Function, Atomic & Molecular Structure, Cellular Structure & Function, Ecology & Ecosystems, Energy & Magnetism, Evolution & Diversity, Health, Heredity & Genetics, Matter & Substances, Plant Structure & Function, Reproduction, Scientific Methods, and Measures & Tools. TERC's web designer then adapted the existing interface for the signing dictionaries to create an interface for the SBD that is compatible with Mac, Chromebook, and a wide variety of platforms and web browsers and with iPads. Figure 1 provides an example of a term page, definition, access to the categories and letter list, and the interactive features available.

Figure 1. Sample SBD page.



3.2. Research procedure for studying use and effectiveness of the SBD and identifying improvements needed

After preparing the SBD, the university team, in consultation with the R & D team, identified three topics and sets of terms to use for testing. These were Reproduction, Heredity & Genetics, and Ecology & Ecosystems. These topics were selected because they incorporate biology terms and content that interpreters are likely to encounter in a variety of academic and non-academic settings. Evaluation incorporated a mixed-measurement design (Cresswell & Plano Clark, 2007; Johnson, Onwuegbuzie, & Turner, 2007) that integrated qualitative and quantitative methods, in which the outcome of interest was measured for participants only.

The university team, under the leadership of the co-PI, had primary responsibility for all aspects of the research associated with incorporating the SBD into interpreter training instruction at Lamar and having students use it to learn signs and practice using them. They also had primary responsibility for data collection. Responsibilities for data preparation and analysis were shared by both teams. The PI from TERC and the co-PI from Lamar collaborated and provided guidance throughout the study.

The study was conducted over 9 months and divided into three units. Each unit focused on terms for one of the SBD topics identified for the study. Unit 1 focused on Reproduction; Unit 2 focused on Heredity & Genetics; and Unit 3 focused on Ecology & Ecosystems. Each unit was done using computers within the Deaf Studies and Deaf Education labs equipped with ScreenFlow (Telestream, n. d.) software to capture participants' use of the dictionary. Research included a pre-session, two study sessions that took place over a 2-week period following the pre-session, and a post-session the week after the end of the study sessions. Each individual session was 2 hours long. To recruit

participants, flyers were posted throughout the Department of Deaf Studies and Deaf Education building. Faculty also announced it in their classes and gave students extra credit for participating. IRB approval for the study was obtained from both TERC and Lamar University's IRB.

At the beginning of the pre-session, participants read and signed an informed consent form. They also filled out a participant information form. This form provided information for use during analysis such as ASL course level and ASL proficiency level. The remainder of the pre-session involved a brief introduction to the unit topic, a matching-vocabulary pre-test, a signing pre-test, and a pre-interpreting sample.

The matching-vocabulary pre-test was a paper-and-pencil test that asked participants to match each of the terms for the unit topic with their definitions. Scores provided baseline information about participants' knowledge of the biology content for the unit prior to using the SBD. For the signing vocabulary pre-test, each participant was asked to sign the terms for the unit topic while a researcher watched and recorded whether the sign was correct or incorrect or if the participant did not know the sign for the term. Scores provided baseline information about participants' ability to sign the terms for the unit topic prior to using the dictionary.

For the pre-interpreting sample, participants were asked to interpret content that was provided by one of the researchers as a spoken language presentation that included slides from a pre-recorded video, to provide consistency across participants. The interpreting sample was video recorded and used for coding and analysis. Scores provided baseline information about participants' ability to interpret material that incorporated the unit terms prior to using the SBD.

At the beginning of the first study session, a university team member demonstrated use of the SBD and distributed a terms list. During the study sessions, participants used the SBD to study and practice terms in the vocabulary list for the unit while ScreenFlow recorded, for example, terms looked up and interactive features used to practice signs and study the meaning of terms. Faculty observed each participant at work and completed an observation form. The ScreenFlow recordings and observations data provided information about how students used the dictionary.

During the post-session participants completed a matching-vocabulary post-test, a signing vocabulary post-test, and a post-interpreting sample that were the same as those used for the pre-session. Differences in before and after scores provided information about the change in participants' knowledge of the topic content and ability to sign relevant terms.

Scoring of the pre- and post-interpreting samples was done as follows: Two interpreters created an overall interpretation score for both the pre-interpretation as well as the post-interpretation. Each of the three units was evaluated and then averaged into an overall score for the pre- and post-interpretation. Each video was scored on five measures using a 5-point scale, with 1 being *poor* and 5 being *excellent*. The measures were fluency, sign production and clarity, fingerspelling production and clarity, conceptual accuracy, and processing time.

Each participant also completed a student participation survey (see Appendix) that provided information about their experiences in using the dictionary and their thoughts as to how it could be improved. Scoring involved tallying Likert-scale responses about satisfaction with features. Particular likes, dislikes, and aspects that could be improved were identified and the number of participants who mentioned each aspect was tallied.

4. Results

4.1. Results for Research Question 1: How do Lamar undergraduate interpreting students use the SBD to learn life science terms?

The observation form provided data for the results for each of the three units (Reproduction, Heredity & Genetics, and Ecology & Ecosystems) related to use of the interactive features and activities related to use. ScreenFlow recordings provided data for the number of terms looked up and average time spent per term. Tables 2a, 2b, and 2c show these results.

Table 2a: Student usage of the interactive SBD features.

Interactive features[a]	Number of students (*N* = 26
Played video/watched avatars	243
Signed with the avatar	61
Found terms using alphabet bar	52
Found terms using search box	22
Found terms using categories[b]	0
Use/scrolled terms list	10
Read English definitions	151
Viewed pictures	22
Listened to audio	5
Used pause, play, rewind	23
Changed text size	1
Used full screen	3

[a] Numbers represent the total number of students the observers saw doing the action while circulating from computer to computer and observing students using the SBD to learn and practice terms during Study Sessions 1 and 2 for the three units combined.

[b] This feature was not demonstrated during the part of the session that involved showing participants how to use the tool.

Table 2b: Activities students performed during use of the SBD.

Activities performed	Number of students
Followed written word list	79
Practiced signing (not watching avatar)	68
Fingerspelled	2
Took notes	107
Reviewed notes	38
Used flash cards	5
Highlighted	2
Drew pictures	1
Asked for clarification of signs	22

Table 2c: Number of SBD terms looked up and average time spent per term.

Unit name and study session number	Number of terms looked up	Average time per term (minutes)
Reproduction: 1	41	2.0
Reproduction: 2	47	2.5
Heredity & Genetics: 1	44	1.3
Heredity & Genetics: 2	18	5.0
Ecology & Ecosystems: 1[b]	32	3.7

[a] Participants looked up terms in an order that suited them. The terms looked up are presented in the order which terms appeared in the ScreenFlow data.

[b] There are no ScreenFlow recordings for Study Session 2 for Ecology & Ecosystems because researchers neglected to turn ScreenFlow on.

Table 2d: Participants' perceptions of SBD use.

Survey Question	***Responses****
How easy for you was it to find information?	*very easy-20, 22, 24; fairly easy-5, 4, 2; possible with trial and error-1, 0, 0*
How easy was it for you to use without help?	*no help-19, 22, 21; some help-6, 4, 5; a lot of help-1,0, 0*
How helpful was the dictionary?	*a lot-25, 23, 25; a bit-1, 3, 1*
How did you use the dictionary?	*learn new signs-26, 26, 24; learn science-16, 18, 21; be able to discuss/explain things-18, 16, 16; understand written information-14, 14, 9; to help do homework-0, 1, 0; hear definitions-14, 20, 7; look up words in English-4, 2, 1*
How did you look at words?	*ASL-26, 23, 24; English text-26, 24 5; voiced-26, 4, 2*
How did you look at definitions?	*ASL-25, 24, 26; English text-24, 26, 25; illustrations-9, 8, 9; voiced-2, 3, 1*
How did you find terms?	*search box-12, 13, 15; alphabet bar-19, 17, 20; categories-1, 1, 1*
Would you like to use the dictionary again?	*yes-26; 26; 26*
Using the signing dictionary was fun.	*agreed-25, 26, 26; disagreed-1, 0, 0*
It made it easier to learn science words/ definitions.	*Agreed-26; 26, 26*
Using the dictionary helped me learn on my own.	*agreed-25, 26, 26; disagreed-1, 0, 0*
Did you use the dictionary to learn new signs?	*yes-26 (reproduction-9; all terms-8; mammary gland-5; sperm-5; scrotum=4; fertilization-4; embryo-3); 26 (chromosome-10; all terms-8; genetics-4; haploid-4; trait-3; DNA/RNA-3); 25 (predator-8; all terms-1; environment-4; ecosystem-3; resources-2*
Did you use it to learn the meaning of a word that you did not know or were not sure about?	*yes- 24 (all terms -6; amniocentesis-4; ascus-2); 25 (all terms-7; all terms-7; chromatid-3; oncogene-20); 22 (all terms-7; estivate-6; heterotroph-2)*

***-**Data are grouped together the for Reproduction; Heredity & Genetics, Ecology & Ecosystems unit

Results for Research Question 1 indicate that participants used the SBD during the study sessions in ways that met their individual needs. Most of them found the SBD helpful and easy to use. They used it to look up terms and

definitions in ASL and English; see words signed; view illustrations; learn new signs; and learn more about science. Only a few used the category look-up or audio feature. Most participants used the SBD to learn new signs and to learn the meaning of a term either because they did not know it or to help them review their knowledge of an aspect of biology content. They were generally satisfied with the information that was available for each term, with the accuracy of the signs, with their ability to understand the avatar, and with the avatar's facial expressions. All of the participants found that use of the dictionary made learning science terms and definitions easier. It also helped them learn on their own. Most had fun using the dictionary and would use it again.

4.2. Results for Research Question 2: How effective is the SBD in increasing Lamar undergraduate interpreting students' knowledge of the vocabulary and their ability to sign life science terms?

The matching vocabulary pre- and post-tests asked participants to match each of the terms for the unit topic with their definitions prior to and after using the SBD. Change in scores provided data about effectiveness of the SBD in increasing participants' knowledge of the unit vocabulary as shown in Table 3a.

Table 3a: Effectiveness of the SBD in increasing participants' knowledge of the unit vocabulary (N=26).

Unit: Pair	**Mean score**	**Standard deviation**	**Standard mean error**	**95% confidence interval of difference[a]**
Reproduction: 1				
Matching pre-test	18.50	8.377	1.643	
Matching post-test	31.73	9.804	1.923	
Pre-/post- difference	13.23	7.112	1.395	Lower: 10.358; Upper: 16.105
Heredity & Genetics: 2				
Matching pre-test	13.58	10.041	1.969	
Matching post-test	23.38	12.293	2.411	
Pre-/post- difference	9.808	5.933	1.164	Lower: 7.411; Upper: 12.204
Ecology & Ecosystems: 3				
Matching pre-test	29.46	10.277	2.016	
Matching post-test	41.96	10.348	2.029	
Pre-/post- difference	12.500	6.288	1.233	Lower: 9.960; Upper: 15.040

[a] See paired differences below.

Paired Differences

Unit: Pair	***t***	***Df***	**Significance (two-tailed)**
Reproduction: 1	9.486	25	.000
Heredity & Genetics: 2	8.429	25	.000
Ecology & Ecosystems: 3	10.136	25	.000

The signing vocabulary pre- and post-tests asked participants to sign the terms for the unit topic prior to and after using the SBD. As the individual signed, a researcher watched and recorded *yes* if the sign was correct and *no* if it was incorrect or if they did not know the sign for the term. Change in scores provided data about effectiveness of the SBD in increasing participants' ability to sign the unit vocabulary, as shown in Table 3b.

Table 3b: Effectiveness of the SBD in increasing participants' ability to sign the unit vocabulary (N = 26).

Unit: Pair	Mean score	Standard deviation	Standard mean error	95% confidence interval of difference[a]
Reproduction: 1				
Signing pre-test	8.92	12.293	2.411	
Signing post-test	56.50	20.217	3.965	
Pre-/post- difference	47.58	22.536	4.420	Lower: 38.475; Upper: 56.679
Heredity & Genetics: 2				
Signing pre-test	11.08	12.834	2.517	
Signing post-test	46.19	17.915	3.513	
Pre-/post- difference	35.12	24.382	4.782	Lower: 25.267; Upper: 44.964
Ecology & Ecosystems: 3				
Signing pre-test	15.85	15.309	3.002	
Signing post-test	57.96	17.505	3.433	
Pre-/post- difference	42.12	16.640	3.263	Lower: 35.394; Upper: 48.837

[a] See Paired Differences below.

Paired Differences

Unit: Pair	*t*	*Df*	Significance (two-tailed)
Reproduction: 1	10.765	25	.000
Heredity & Genetics: 2	7.344	25	.000
Ecology & Ecosystems: 3	12.905	25	.000

The results for Research Question 2, as shown by the change scores, indicate that use of the SBD resulted in increased performance in participants' knowledge of the unit vocabulary and ability to sign the terms. Although the standard deviations for participants' before and after knowledge of the unit vocabulary and their ability to sign it show a high level of variability, the paired *t* tests for the change in vocabulary knowledge and signing ability confirm that both increased with use of the SBD.

4.3. Results for Research Question 3: How effective is the SBD in increasing Lamar undergraduate interpreting students' capacity to accurately and clearly interpret content typically taught in undergraduate biology courses?

As described, each of the three units was evaluated and then averaged into an overall score for the pre- and post-interpretation. Each video was scored on five measures using a 5-point scale, with one being *poor* and five being *excellent*. The measures were fluency, sign production and clarity, fingerspelling production and clarity, conceptual accuracy, and processing time. Averages of pre- and post-interpretation scores for each unit show the mean score for the pre-interpretation measures as 11.2 out of 25, with a range of 5 to 20 and a standard deviation of 4.2. The mean score for the post-interpretation scores was 11.0 out of 25, with a range of between 5 and 20 and a standard deviation of 4.3.

Because there were no changes across the participants, correlations were conducted on the post-interpretation scores using Spearman correlations, because the background variables were categorical. The only significant correlation that emerged was year in program and ASL level (r = .66, p = 0.01; two tailed). This relationship is colinear in that for many of the students, year in program was related to their class level of ASL. It is not perfectly

colinear because many students entered the program with higher levels of ASL skill while others entered having never taken an ASL class prior to enrolling in the program.

Both variables (year in program and ASL level) were entered into a regression analysis using SPSS. Only ASL level was significantly related to the outcome. Therefore, a simple regression was rerun and is shown in Table 4.

Table 4. Analysis of the variables of year in program and ASL level.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	6.051	2.250		2.689	.013	1.385	10.717
	ASL level	1.285	.537	.455	2.395	.026	.172	2.398

a. Dependent Variable: Post Interpreting Scores

The *R* for this model is .455 and the *R* square is .207. Therefore, ASL level predicts a bit more than 20% of the variance in the post-interpretation measure.

The results for Research Question 3 indicate that only two participants were able to produce a fluent interpretation. These students incorporated classifiers into interpretations and demonstrated an effective use of space. The other 24 participants were unable to effectively follow the typical pace of a biology lecture. Many made sign production errors while interpreting. In addition, their signs were not conceptually accurate, they used almost no classifiers, and they were unable to effectively set up items in a spatial grammar. Their fingerspelling was also not smooth.

The two students who were able to produce a fluent interpretation were in the fourth year of the program. The other participants were in lower level ASL classes and had not yet developed the ability to produce a coherent interpretation. These results suggest that being able to keep up with the pace of a typical biology lecture and interpret it is a two-step process. The first step involves learning the content for the terms and the sign vocabulary related to this content. The second step is learning how to integrate this knowledge to produce a fluent and accurate ASL interpretation of the content being presented.

4.4. Results for Research Question 4: What additions and/or changes would make the SBD more effective?

The survey of student participants provided data for the results related to participants' level of satisfaction with features that were incorporated into the SBD, things they liked and did not like, and aspects that could be improved as shown in Table 5.

Table 5: Participants' Level of Satisfaction with the SBD

Survey Question	***Responses****
How satisfied are you with: information available for each term?	*completely satisfied-20, 24, 25; somewhat satisfied-4, 2, 1; not satisfied-0, 0, 0*

accuracy of the signs? *understanding of the avatar?* *avatar's facial expressions*	*completely satisfied-17, 15, 15; somewhat satisfied-7, 11, 10; not satisfied-0, 0,1* *completely satisfied-10,9,8; somewhat satisfied-13, 16, 17; not satisfied-1, 1, 1* *completely satisfied- 16, 12, 15; somewhat satisfied-6, 14, 10; not satisfied-2, 0,1*
What are examples of signs that were not accurate or made them hard to understand?	*signs varied for some words which was confusing-3, 4; struggled to understand a sign-3, 2 (sign for "sugar" as it was old),*
What do you like about the dictionary?	*options for learning-11, 4,0* *bilingual (available in ASL and English)-11, 8,10* *learning independently at own pace-3,1,0* *can re-watch/replay as often as you want-3, 3, 3* *accessibility-3, 3, 0* *ease of use-11, 8, 6*
What do you dislike about the dictionary?	*avatars are difficult to understand-8, 5, 7 (choppy; lack of contrast in skin color and clothing)* *no way to slow the video-2, 6, 5* *do not like avatars, prefer a person-2, 0, 0* *not all terms within the definitions were not included-2, 0, 2* *signing more English than ASL-0, 2, 0*

***-**Data are grouped for Reproduction; Heredity & Genetics, Ecology & Ecosystems

Results show that most participants were generally satisfied with the information that was available for each term, with the accuracy of the signs, with their ability to understand the avatar, and with the avatar's facial expressions. Some preferred a human signer to an avatar or found the avatar difficult to understand. Some found the signing choppy and the contrast between clothing and skin color insufficient, and expressed that this interfered with seeing the signing. Others mentioned not being able to change the signing speed as a drawback. Some would like all of the terms in the definitions included in the word lists and the signing for some of the terms to be updated and reviewed for accuracy in context of use.

5. Discussion

This study of first-time use of the SBD among interpreting training students shows that the SBD contributes to students' ASL life science vocabulary and ability to sign life science terms. Such knowledge may, however, benefit only those students who are in the advanced level of the program and can keep up with the pace of a typical undergraduate biology lecture and accurately and clearly interpret the content. Student interpreters in the lower levels of the program may not yet have achieved the fluency in ASL to make effective use of the ASL life science vocabulary included in the SBD. Findings also indicate that the dictionary's interactive features promote individualized learning for students in all levels of the program, and makes the learning of life science terms and definitions easy and fun.

6. Limitations and further research

The present study has some important limitations. The findings of this study of SBD use cannot be generalized to all interpreting students in the Lamar program, nor to interpreting students in other programs. A larger, more representative sample of Lamar's interpreting students from all levels of the program is needed, as well as samples from 2-and 4-year programs in other parts of the country. Additionally, the present study focused on use of a first version of the SBD and was intended to provide preliminary information and insights into the use and benefits of the intervention, as well as to identify how it could be improved. Additional research is needed to further evaluate the SBD to identify signs that have evolved or are conceptually inaccurate and to examine use of an avatar rather than a human signer. Only then will we begin to discover the true benefit that use of the SBD adds to the preparation of interpreting students.

7. Conclusion

Conducting a first-time study of use of the SBD enabled researchers to begin to see first-hand the benefits and challenges that exist for interpreting students in learning ASL life science vocabulary and using it to interpret undergraduate biology course content. We were able to see how students use the SBD and integrate it into their learning of ASL life science terms and gained insight into how an interactive signing dictionary that incorporates a comprehensive set of life science terms can affect interpreting students' learning. Although this study provided important information about use of the SBD to improve student interpreters' life science vocabulary, additional research at Lamar and in a wide range of programs is needed to explore and assess the SBD's full potential. The SBD is available free from https://signsci.terc.edu/video/SBD.htm .

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