ASL CLeaR: STEM Education Tools for Deaf Students

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ABSTRACT
In this paper, we introduce the American Sign Language STEM Concept Learning Resource (ASL CLeaR), an educational application demo. The ASL CLeaR addresses a need for quality ASL STEM resources by featuring expertly presented STEM content in ASL, and employing an ASL-based search function and a visually-centric search interface. This paper discusses the main objectives of the ASL CLeaR, describes the components of the application, and suggests future work that could lead to improved educational outcomes for deaf and hard of hearing students in STEM topics.

Categories and Subject Descriptors
K.4.2 [Computers and Society]: Assistive technologies for persons with disabilities

General Terms
Design, Human Factors.

Keywords
American Sign Language, ASL, STEM education, deaf.

1. INTRODUCTION
All deaf and hard of hearing children are potential American Sign Language (ASL) and English print bilinguals, if immersed in complete and fully accessible language from early ages [6]. However, deaf children face a formidable array of linguistic challenges, beginning with delayed first language input [7] due to limited exposure to sign language. Lack of early accessible language leaves a high percentage of deaf children lagging non-deaf peers in educational outcomes, and is shown to pose serious issues for STEM learning [9,10], and proficiency with written English. Exacerbating the challenges of educating a population with language delays, many STEM concepts do not have an agreed upon ASL sign. Deaf students often learn different signs for the same STEM concept from one classroom to the next. Imagine a fourth grade teacher using a different term for “Photosynthesis” than the third grade teacher, without discussing the change in vocabulary.
In addition, signs generated on the fly are often grammatically incorrect, resulting in learning materials that are not easily comprehensible, conceptually accurate, or engaging in ASL.

2. ASL CLeaR
The ASL STEM Concept Learning Resource (ASL CLeaR) is a free online resource intended to serve as both an educational tool and a language documentation and standardization effort. ASL CLeaR creates a mechanism for broadly sharing a collection of fluent, accurate and engaging ASL STEM lectures and a complete

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Table 1. Comparison of online ASL STEM applications¹

| ASL dictionary of terms. It provides an avenue for curricula and language coordination among deaf students, parents, education professionals, and within the deaf community nationwide. It features both ASL-only as well as English navigation and search, provides context in ASL, is vetted by native (L1) ASL STEM domain experts, and uses human signers. The ASL CLeaR is also unique in its exploration of deaf geographies in web design. Universal Design and visually motivated signed language principles [1]. Three main components of ASL CLeaR are described below.

2.1 Topic Labs
In topic labs, Deaf L1 ASL STEM and education experts lead all content development efforts and generate materials that adhere to curriculum guidelines, model effective, engaging and standardized STEM instruction in ASL, and are designed to improve content and vocabulary learning among deaf students [2]. The expertise of the team ensures that we avoid the linguistic and conceptual issues commonly found in signed content online. Topic lab materials have been used to build the ASL CLeaR video collection and the ASL STEM dictionary. All ASL STEM terms, whether newly coined or widely accepted, are internally evaluated by the ASL CLeaR team for grammaticality and conceptual accuracy. Terms that meet criteria are first introduced and defined in the instructional context of an ASL STEM micro-lecture. Next, ASL dictionary entries for approved terms are composed and filmed by the content team. Entries include a stand-alone sign, an ASL definition and, in specified cases, an example. Each STEM sign is tagged with ASL linguistic meta-data in the Coding Tool (not depicted) to make the sign searchable via ASL features. At this point, a complete ASL entry has been created. To enable English print searches and bilingual search results, each ASL term is associated with its closest English translation and an English print definition, then tagged with English print metadata.

2.2 Vocabulary Evaluation Tool
To increase the likelihood of broad acceptance of ASL STEM terms, materials are first evaluated by L1 ASL STEM domain experts nationwide. To facilitate scaled evaluation, an online application has been developed, the ASL CLeaR Vocabulary Evaluation Tool (VET). The VET design filters content to give raters access only to material that aligns with their expertise. VET navigation is entirely ASL-based (Figure 1a), establishing the correct monolingual ASL frame for evaluations and preventing reliance
on English labels to ascertain meaning of ASL terms. The VET
steers evaluators through a sequential protocol that repeats until
all terms from a unit are evaluated: 1) view one complete micro-
lecture, 2) view one ASL term from that lecture, 3) view ASL
definition for that term, 4) view ASL example if provided, 5)
respond to 7 ASL evaluation questions about the term by selecting
from 5-part Likert scale or yes/no options (Figure 1b). In a small
pilot (n=5), 16 of 20 terms scored at or above benchmark (M=4),
suggesting potential for broad acceptance.

2.3 ASL CLeaR Search Function & Interface
The ASL search function and interface makes this a unique da-
tabase that offers ASL search functionality via graphical representation
of the string of visual building blocks that make up ASL signs, much like alphabetic print graphically represents the string
of sounds that makes up a spoken word. ASL searches of tagged
terms are conducted by selecting icons in three ASL feature arrays
(Figure 1c). Clicking on any icon will bring up a results screen
displaying all signs that contain the select feature, a design that
provides instantaneous results and interactive training through use.
Search results are presented in alignment with the principles
of visual language. Freeze frames depict ASL STEM terms in
recognizable form and hover play allows users to quickly scan,
reject, and select terms from the results page. ASL CLeaR also
provides STEM words in at least 3 ASL contexts to prevent the
denotation and connotation confusion of single English word lab-
eling. For example, a sign defined only with English word table
could refer to an item of furniture, a chart, or a level (e.g. water
table). Many users do not have the foundation to rely on contextual
knowledge to bridge the information gaps, particularly early
deprived deaf children [8].

3. RELATED WORK
Seven U.S. online resources attempt to respond to the challenges
faced by deaf students learning STEM (Table 1)1. While five sites
attempt to resolve denotation confusion by associating signed
terms with English definitions, this does not address connotation,
provide ASL context, or constitute a monolingual ASL dictionary
entry. Existing resources do not answer questions often asked by deaf students and educators relating to ASL connotation and cor-
rect usage of STEM signs in instructional contexts. DeafTEC
offers signed definitions of STEM terms, but these do not consist-
ently adhere to ASL grammatical rules; rather English syntax is
imposed on borrowed ASL lexicon. Another proof of concept

4. CONCLUSION
The ASL CLeaR provides complete, accurate, academically rig-
orous and standardized bilingual access to STEM material pre-
seminated in instructional contexts by Deaf STEM experts, which will
facilitate deeper understanding of academic content [4,5]. For K-
dead children, parents, and educators, the ASL CLeaR offers a
rare opportunity to build understanding from the most basic STEM content to the most complex. The ASL CLeaR models consistent use of a single ASL term to represent a single concept such as photosynthesis in varying contexts. Deaf children deserve resources that build solid foundations in core STEM content and vocabulary, contribute to fundamental understandings of how the world works, foster logical, analogical and inference-making skills, open the door to post-secondary education, and lead to satisfying careers in STEM fields.

5. REFERENCES

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