Role of Technology in Increasing Representation of Deaf Individuals in Future STEM Workplaces

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ABSTRACT

Deaf individuals are still largely underrepresented in most workplaces, particularly in STEM fields. The HCI community can develop well-designed workplace tools that could have a significant impact on individuals quickly, by utilizing current feasible options, designs, and features in innovative ways. Such an effort has the power to create environments and platforms that meet their needs, expectations and supplement classroom-based, lifelong, and career-related education, enabling deaf people to learn and achieve to their fullest potential. In this paper, we highlight existing barriers preventing full participation in the workplace in sign language (SL), and describe how our work supports building the STEM capacity Deaf individuals seek, contributing to greater participation in fields where they have been underrepresented. We also discuss sign language-centric user interface designs and research, highlighting how HCI research can contribute to the development of future workplace digital tools mainly for remote and hybrid work settings.

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1 INTRODUCTION

With the growing workforce demand in STEM fields, it has become a national goal in the U.S. to broaden participation in STEM fields [1]. Given educational access and opportunity, Deaf people have demonstrated equal potential to lead successful careers in STEM fields and make strong contributions [25, 26]. However, for deaf students whose access to STEM curriculum is compromised by language-related, institutional, and societal barriers, the prospects of a successful STEM career are drastically reduced [7, 8, 11]. Deaf people most often encounter potential employers and human resource departments who have very limited or no experience working with deaf individuals. They are likely to find themselves screened out of the interview process far more quickly than other candidates. After being hired, deaf employees may not feel welcomed or be fully included in the workplace, due to a wide variety of factors, many well-described by Braun et al about the experiences of deaf students in university settings [11].

The proportion of deaf and hard of hearing people working in STEM fields reported by NCSES in 2011 was 0.13 – 0.19% compared to 11 – 15.3% in the general population [15–18, 31]. In addition to barriers related to misperceptions and bias, deaf people also find limited access to STEM content in ASL, including instructional and workplace materials, technical communication, and specialized training.

These longstanding factors, if unaddressed, will perpetuate the continued loss of much potential talent from an underrepresented group that indeed has proven ability and contributions with many notable achievements in STEM [25, 26]. These problems are two-fold, firstly, lack of resources and tools that deliver STEM educational materials in Signed Languages (SL) limit participation from the deaf community and secondly, lack of workplace tools such as online hiring procedures, surveys, exclude qualified deaf individuals. Steps taken to establish a foundation for future user interface toolkits will create a pathway for expanding benefits because it facilitates development of SL user interfaces by others. In this paper, we discuss barriers and challenges that exist for fully participating in work in signed languages, our SL-centric STEM education tool, and general SL-centric user interface designs and SL-centric research for development of future tools needed to support Deaf individuals in hybrid work environments places.

2 RELATED WORK

Our work contributes to the HCI and computing education literature on broadening participation in computing, which strives to bring programming to more diverse populations. CSCW, CHI and ASSETS communities have studied the experiences of what is sometimes labeled 'mixed-ability' teams in the workplaces and highlighted problems surrounding challenges around communication

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and inclusive collaboration [4, 29, 40]. Mohler et. al. [36] highlight the barriers students with disabilities face when entering STEM and how these challenges extend through their education to the point of employment. These challenges begin with access to education tools [36]. Additionally, recent survey data from StackOverflow shows that about 28% of their users have a physical disability and 0.77% identified as Deaf and Hard of Hearing[3]. Moreover, online resources such as videos, blogs, were listed as the top method to learn programming and coding [3]. This further highlights the need to develop tools that support the learning needs of Deaf programmers. HCI research can help by developing tools that support and encourage education. We focus on online education tools that allow both learning, and referencing, that is, tools that allow quick access to specific information. These reference tools, are essential for the workplace environments.

Remote work has become more common and acceptable after the pandemic hit [37], but careful attention is needed to ensure that this new mode of work is accessible for all. According to the CDC, 26% of American adults have disabilities [2], which means many individuals who carried out this quantum leap of work nature have different abilities. That reinforces the clear need to support accessibility. Efforts have been made to study the challenges that people with different abilities encounter when communicating remotely [38]. Some researchers specifically studied how deaf individuals communicate in remote work settings [24]. Some of the challenges faced by deaf members when using video calls were highlighting speakers, visual layout, thumbnail videos when in screen sharing mode [38].

Previous work to support signed language technology to support Deaf individuals has looked at translation challenges [7] or different ways for delivering ASL content such as developing written or animated ASL characters [10] or creating avatars [5, 27]. In addition, some studies investigated methods to make text-based content accessible for deaf users, such as the embodiment of the tool-tip [23, 32] or the use of Automatic Text Simplification (ATS) tool [6]. While, Joy et. al [23] designed a video tooltip to pop up when hovering over a word to reveal its equivalent sign, Petrie et. al [32] made use of the tooltip to display the matching sign for webpage icons to enhance the clarity of the user interface elements. Thus, they eliminated the need for switching pages to look up the meaning of a word or icon. Also, [6] explored Automatic text simplification (ATS) tool for deaf and hard-of-hearing (DHH) individuals in the computing field.

While automatic sign language recognition, generation, and translation is challenging [9], we are interested in how HCI research can develop supportive tools with existing technologies.

In this paper, we discuss the design and development of future user-interfaces and tools that will allow user-friendly layout, navigation and searching of ASL education content in video form. We focus on the STEM education tool needs and the role HCI can play to increase support in online STEM education for Deaf Users. We also discuss the future development of work tools that can deliver signed language content in a user-friendly signed-language centric manner.

3 BARRIERS THAT EXIST FOR FULLY PARTICIPATING IN WORK IN SL

The following section describes the experience and challenges our team with both Deaf signing members and hearing members. We work together remotely via video conferencing. Together, we are working towards defining guidelines for novel SL-centric user interfaces. We conduct user studies to create tools to conduct research and STEM tools to broaden Deaf participation.

3.1 Accessibility in remote work

The pandemic has changed the ways and methods of work. Remote work allows for collaboration flexibility and removes travel and location constraints. We found it easier to find interpreters for our meetings because of this looser location constraint, which allowed us to meet more frequently. However, we encountered new issues with video conferencing platforms and remote work.

3.2 Communication and Language

Interpreters help us while communicating by translating back and forth between ASL and English. We have observed that despite interpreters being highly skilled, at several instances translation of technical or research related work is hard. We often need to rely on our bilingual hearing team members who know both ASL and English to support the interpreters translations. This is caused partly due to the differences in the language structure, and due to lack of direct translation for some words. This problem extends into conducting user studies. Several rounds of editing and reiterating is required to translate the user study protocols. Broader Deaf participation in research and workplaces in the future will mean the need to have well-defined terminology agreed upon by HCI experts, researchers and linguists.

3.3 Platforms/Tools

Current video conferencing tools that support remote work do not align perfectly with the needs of Deaf users. For example, some video conferencing platforms have audio-centric features, such as highlighting the speaker instead of the signer and not allowing the user to reorganize the video tiles (putting the interpreter in the middle for example). Recent updates have solved some of these issues, reducing barriers for Deaf and ASL signing users (e.g. spotlight, pin/multi-pin, switching between gallery and speaker views). However, some added features present barriers, for example, the repeated requests to unmute at unnecessary times and spotlighting of audio source (e.g. English-speaking interpreter), when the signer is using ASL and should be spotlighted.

Deaf individuals have different workarounds to make the current video conferencing tool accessible. For example, one chooses to use the grid view to see all signers, while another may display the currently active signer. Another example of Deaf people's experience with the available video call platforms is that some signers use two screens—a screen for displaying the signer and another for displaying the content such as slides. Kushalnagar et. al [24] discuss these differences and more, and suggest tips that help create a relatively smooth user experience. Their work illustrates how the Deaf user

experience is entirely different from the hearing users which indicates a clear need for different conventions for developing remote work platforms to support Deaf users in work environments.

These issues are also prominent while conducting HCI related work such as designing high fidelity prototypes, conducting user studies, and analyzing qualitative data. Since the primary source of signed language information delivery is videos, we set out to create prototypes with videos. However, significant overheads exist while dealing with large video data. Popular platforms for creating prototypes offer limited support for videos, problems include limitations on video file sizes and quantity, and insufficient or glitch-filled support for features like video playing on mouse hover. Conducting user studies online and creating surveys present further challenges due to inadequate support from platforms [30]. Additionally, analyzing qualitative data after being translated may result in data loss due error in translation and also loss of facial expressions which are a key part of sign language communication. In the future we need to develop protocols, methodologies and tools that support both the research related to developing SL-technology and carrying out research with Deaf participants.

4 STEM RELATED RESOURCES AND PLATFORMS

The use of online resources for learning and using as references is increasing, however, there is a lack of resources in Signed Languages. Such tools are used in work contexts for searching and referencing material everyday. Online learning platforms have captioned video content, but it is often insufficient, adding challenges for viewability for Deaf users. There are very few resources that deliver STEM content in signed languages, lack of these resources creates problems in learning. Therefore, there is a need to develop resources that can deliver SL STEM video content in an accessible and user friendly way. Even though the technology needed to design and deliver video content is available, the current features tools and platforms are not combined in such a way that we can develop them easily. For example, YouTube allows users to create, upload and search video content, however, other features that would add scannable SL-based elements are not present, such as signed-freeze frames, or visual icons. Addition of such features would help in making the platform SL-friendly. These problems highlight the need for developing online SL STEM tools that can support members of the Deaf community in education and learning to allow continued success in their careers.

4.1 ASL Clear: An Example of an Online ASL-Centric STEM Education Tool

In this section we discuss ASL Clear, an online application that was developed to address the need of STEM related online educational resource in ASL [33]. It serves as both a resource to support STEM education and reference tool for future workforce development as well as a real-world example and test-bed for exploring user interface design that is centered on sign language, instead of retrofitted for sign language.

It is depicted in Figure 1. The current design of the ASL Clear allows users to navigate and search a STEM educational application containing ASL content. The STEM units in ASL include micro-lectures, STEM terms, definitions, and examples. The monolingual ASL UI is designed for, around and in the linguistic principles of ASL.

Initial designs for the ASL Clear have been created [33], however, building on this initial demo, the user interface has been systematically examined and modified to ensure it meets the needs of deaf individuals. From small pilot studies and informal feedback with deaf participants, we have been able to get preliminary feedback on design elements. This version includes STEM videos divided into separate Science, Technology, Engineering and Math categories, these are depicted by four large image icons.

The layout, navigation and search functionalities of this website aim to deliver signed-content in an intuitive way to signers. The menu items Figure 2 and the search Figure 3 are also constructed in ASL along with the content itself.

While ASL Clear is one example that provides STEM learning and referencing resources in ASL, other tools need to follow this ground up approach while designing future tools for education and workplace for inclusion. This would allow smooth access of resources and easy navigation for deaf users. Such ground-up design that is linguistically and culturally appropriate needs careful design.

5 INCLUSIVE FUTURE OF WORK RELATED TOOLS

To better support signing members of the Deaf community in workplaces, we will need to develop tools that allow delivery of signed language content in a sign-language centric way. ASL-Clear is an example of one such tool, in the future, HCI research can help develop tools that can provide access to information to support continued learning and support online work in signed languages.

5.1 SL-centric Tools and Interfaces

One major difference between signed languages and those in spoken or print form is the complex, layered, and temporal nature of linguistic expression. The very different nature of sign language, represented in the hand shape, movement, signing position, angle, and facial expressions calls for different user interface design considerations than the current considerations that have been developed with hearing users in mind [12].

There are limited work-related resources in sign language. Signed language educational resources, social media content, linguistic corpora, and dictionaries have traditionally been organized, shared, and viewed through English-centric UI conventions for layout, search, and navigation. Below, we discuss SL-centric user interfaces and the main questions specifically related to the future development of SL-Centric layout, navigation, and search in a user interfaces for tools of future work-places.

5.2 Rethinking Layout and Navigation in SL-Centric UIs

User interface *layout* and *navigation* for SL content has not been studied or discussed thoroughly in the literature beyond specific use cases [20, 28]. Much more research and development is needed to better understand effective design and conventions for displaying

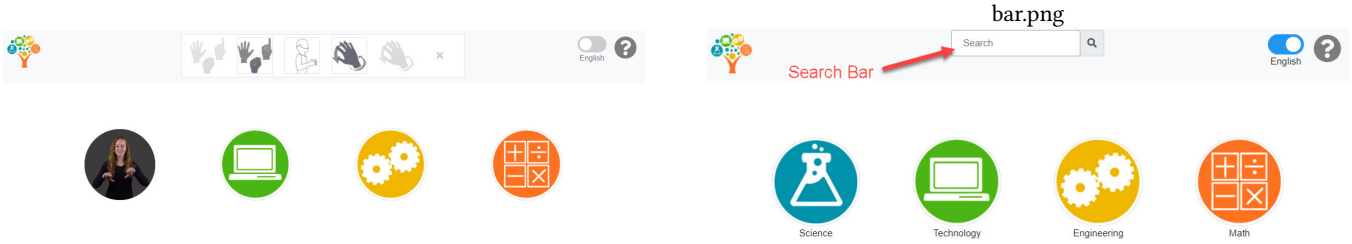

Figure 1: ASL Clear Layout in (a)ASL-only mode and (b)English mode

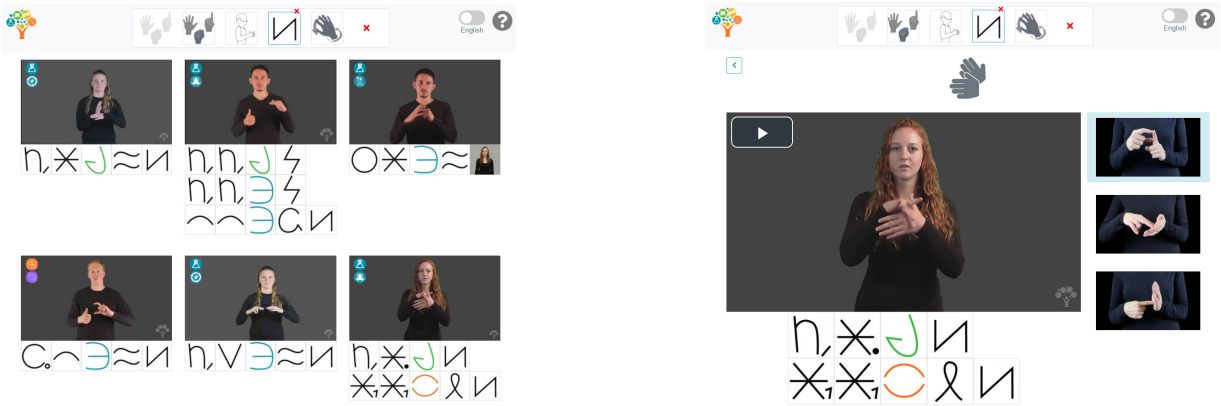

Figure 2: ASL Clear Layout and Navigation. (a) ASL Clear search results layout, showing graphemes selected in search bar above, and freeze frames of sign results with graphemes below (b) Layout of related content page, showing an ASL term in main window with its graphemes below, and in the scrolling panel to the right, ASL navigation buttons users may click on to view the definition or example for the term in the main frame.

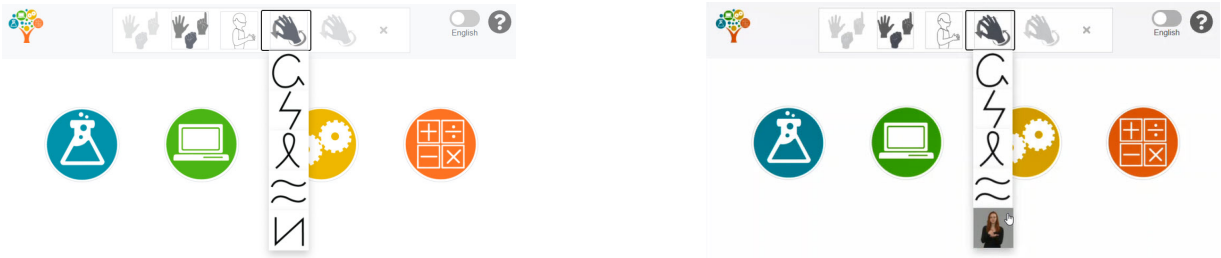

Figure 3: ASL Clear Search. (a) Graphemes showing the different hand movement. (b) Every hand movement is also represented as a video of a signer when hovered over.

SL content [9, 21]. However, in order to make SL-Centric user interfaces for work-related tools a realistic option for Deaf individuals, further study, technical development and refinements of *navigation* and *layout* are needed.

The user interface *layout* indicates the importance of each item, using spatial relationships, placement, color, images, size, and other design choices to guide users to the information sought and facilitate scanning and readability of content. In addition to overall layout, creating a clear and well-organized *navigation* process is a critical element in supporting a satisfying user experience. *Navigation* of a website involves a set of controls built into the user interface with the goal of enabling users to engage easily with the design, then move through it quickly, smoothly, and reliably.

Deaf people typically navigate information, educational content, and assessments solely through their second language (e.g. English) in text form [19]. Studying and identifying best practices and standards for SL-based user interfaces will address this issue.

5.3 Exploring Search Functionality in SL-Centric UIs

Designing an SL-centic *search* function is as challenging as any other UI elements. However, more guidance can be found in the

literature and the experiences using ASL sign analysis systems reported by ASL-signing individuals. Researchers and educators have made efforts to create and implement dictionaries of signed languages and organize them via SL linguistic principles for at least four decades [13, 14, 22, 34, 35, 39, 41]. Despite great strides made to date, not a single exemplar of a fully mono-lingual SL-centric online search function was found, even in SL dictionaries, a clear demonstration of the challenges involved. Computer sign recognition is not yet sophisticated enough to allow users to 'enter' a sign (e.g. via a laptop camera) and reliably find a match in a database. Entering a sign to find multiple appearances of that sign in a long text, or locate a website, will take substantially more research and development.

5.4 SL-centric Research for developing SL work related tools

The other aspect of developing future work related tools is to conduct research with the involvement of members of the Deaf community while designing these tools. We need employ methods like participatory design methodology to help improve inclusivity and accessibility in future work contexts.

6 CONCLUSION

In this paper, we highlight the barriers Deaf individuals face while pursuing STEM related careers from education level to the workplace. We believe that with the current technology, and HCI research, we can build better resources, platforms and user interfaces to better support Deaf individuals in the future work contexts while ensuring the involvement of members of the signing Deaf Community.

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