Creating a Survey Tool for Users of American Sign Language

A Major Qualifying Project (MQP)
Submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of requirements for the Degree of Bachelor of Science in Computer Science.

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Abstract

We created the ASL Survey Tool, a platform designed to make and distribute surveys that use only signed video content and non-textual elements. With the goal of allowing signing users to actively participate in a survey using their primary language, we prioritized the experiences and opinions of the Deaf Community throughout the development process. Using the results of previous studies and feedback from our signing collaborators, we transformed existing prototypes into an ASL-centric survey website. We then conducted an unmoderated user study in ASL with the survey tool to assess its usability and the intricacies of the study process. This marked a crucial step in understanding the tool's potential to increase the Deaf Community's participation in research studies and beyond.

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1 Introduction

1.1 Motivation

In an increasingly interconnected world dominated by technology, linguistically accessible user interfaces are necessary to create equitable user experiences. However, many online technologies fall short. For members of the Deaf Community, resources are often not available in their signed language. There is a significant lack of applications whose design considers people who primarily communicate in American Sign Language (ASL), posing a barrier to these users seeking first-language interactions with the digital world. Tools that use only English do not provide signers with the full, rich experiences of engaging online in ASL.

There has been technology designed in the past by, with, and for people whose first language is ASL, referred to as Sign Language First (SL1) technology. For example, the ASL Education Center (AEC) manages ASL Clear, an online educational resource for science, technology, engineering, and math in ASL by deaf STEM experts (Reis et al., 2015). This ASL-centric interface allows learners to engage via a set of rich ASL instructional videos, images, and other visuals (Figure 1). This platform is not only an advancement in online learning for deaf students but also an effort to document STEM education in ASL.

Figure 1 - Sample Interface in ASL Clear

While a resource like ASL Clear offers an innovative user interface design, SL1 technology often lacks well-researched, effective, and published design principles. Since signed languages are built on body, face, and hand movements (rather than print or sound in written or verbal languages), many design approaches are rendered ineffective. To bridge this gap, designers need to either be Deaf and/or ASL signers, work in teams led by Deaf and ASL-signing experts, or collaborate directly with ASL-signing users and experts. This approach sets the stage for the development of SL1 technology with the opinions and preferences of the Deaf Community at the forefront (Abdulghafoor et al., 2015).

To properly collaborate with the Deaf Community, all project team members and study participants should have the choice to engage in ASL. When it comes to researching and designing SL1 technology, this specifically applies to usability testing and questionnaires. Having the target user demographic fully and comfortably participate in studies is necessary for understanding and meeting their needs. This is where the idea for an ASL-centric survey tool originates from. Conceptually, this tool would allow for taking a questionnaire solely in ASL, meaning that questions and answers would be videos rather than written text. Common symbols and icons would also be used to clarify how the user can interact with the application. This survey technology did not exist prior to this project, showing the need for its development.

1.2 Project History

The creation of an ASL-centric survey tool has been an ongoing process for several years. The original project started with funding under a National Science Foundation (NSF) award granted in late 2019. The award was centered around investigating user interfaces based in sign language. This included design guidelines along with the viability, impact, and challenges of

creating this type of technology. The overarching theme of the grant is for this new area of research to open the door for the development of new accessible technology with members of the Deaf Community at the center of the process. All of these ideas continue today to be a significant part of the project overall.

In 2020, research under this grant began with a Major Qualifying Project (MQP) group at Worcester Polytechnic Institute (WPI) attempting to create general SL1 technology for the Deaf Community (Santacreu, 2021). The primary researcher sent out Qualtrics surveys to assess their opinions on the user interface of pre-existing SL1 technology. However, it was quickly realized that Qualtrics was built to support text surveys with the occasional image or video, not a survey composed entirely of videos. Users found that surveys took a long time to load, required many clicks, and necessitated scrolling to see each video, as they did not all fit on a single screen.

From this negative feedback originated the initial idea of a survey tool designed for ASL. In 2021, a new WPI MQP group worked on designing and prototyping the tool (Cordova and Henriques, 2022). They created low-fidelity and high-fidelity prototypes, working continuously with the AEC collaborators to receive feedback in the iterative design process. Their attention was particularly focused on prototyping several different designs for each question type: multiple choice, multiple select, and scalar questions. Once completed, these initial designs were then tested in user studies.

Alongside these projects, researchers in WPI's Human-Computer Interaction (HCI) Lab and the AEC have contributed to the tool's design and development. As the project has evolved, papers have been published in the proceedings of conferences such as the ACM CHI Conference on Human Factors in Computing Systems (CHI) and the ACM SIGACCESS Conference on Computers and Accessibility (ASSETS) (Boll et al., 2020, 2023; Mahajan et al., 2022).

1.3 Problem Statement

This project aims to (1) build upon previous and ongoing research conducted by WPI and the AEC to develop a fully functional ASL Survey Tool web application, and (2) evaluate the intricacies of conducting an unmoderated user study in ASL with the tool. Achieving these two goals will contribute to creating a linguistically equitable experience for the Deaf Community in research and beyond.

2 Background

2.1 American Sign Language

The richness of Deaf culture can be seen through its associated primary mode of communication, signed languages. In the United States, American Sign Language (ASL) is the primary language of a significant portion of the Deaf Community. Since for many native signers, there are no barriers to its comprehension, it is deeply valued. A common misconception is that ASL is a direct translation of English, but it is not. ASL is a complete, complex, and different language with a grammar, lexicon, and text structure that is conveyed in a visual modality. The phonemes, morphemes, and grammar of ASL are made up of linguistic elements that include handshapes, movements, and facial expressions. For example, adverbs in ASL are created by varying the intensity or speed of the sign or by adding a facial expression to convey the intended quality of the verb (Lapiak, n.d.). Just like any other language, ASL is a system of expression and structured communication.

ASL's regional diversity within the United States is evident in the development of distinct regional vocabulary and dialects. Similar to other signed and spoken languages, there are variations of the language used around the United States. For example, the signs for "birthday" and "soon" vary between different locations (Vicars, n.d.; Lapiak, n.d.). This regional diversity contributes to the intricate nature of ASL as an integral part of American Deaf culture. For many members of the Deaf Community, ASL is not just a language, but also an essential part of their cultural identity, fostering a deep connection to their community and its cultural landscape.

This cultural landscape is deeply rooted in what is known as Deaf culture. The World Federation of the Deaf defines Deaf culture as the "beliefs, attitudes, history, norms, values, literary traditions, and art shared by deaf people in the same community or country" (World

Federation of the Deaf, 2016). A main part of Deaf culture within the United States is the fact that the community shares their signed language of ASL. As a linguistic minority, Deaf individuals use ASL not only to engage with others but also as a means of preserving and celebrating their cultural identity.

Cultural identity within the Deaf Community also manifests in educational settings. The design and development of applications tailored specifically to ASL signers is imperative for creating linguistically equitable learning environments. Literacy in one or more languages is a fundamental skill and a powerful tool for all individuals, fostering independence and reducing reliance on others. Traditional education systems often do not have the approaches or tools to effectively teach language (whether that be ASL or English) or specific subject areas to deaf students. Educational systems for the Deaf are riddled with complexities and barriers to effective learning (Abdulghafoor et al., 2015). In this context, SL1 technology has the power to enhance learning experiences and allow students to study in their primary language of ASL. Such an education would not only strengthen linguistic skills but also prepare students for more complex academic learning, careers, and engagement in areas that interest them.

2.2 Sign Language First Technology

Due to the distinct and essential needs of the Deaf Community, it is necessary to create technology that is designed specifically for ASL. SL1 technology research aims to address the need for developing applications that cater to the language and culture of this community by putting signing users at the forefront of its development process and user experience.

The creation of this technology, however, is not a simple task. It is imperative to understand the cultural and linguistic nuances in the language, such as issues of authorship,

representation, and privacy (Boll et al., 2020). In ASL, signers are seen as the sole authors of the information they convey, raising questions about attributing authorship in video-based applications. Representation also becomes a key concern as the author's identity is evident in a video, potentially impacting how users respond and interact. Privacy is another critical issue; facial expressions are integral to ASL grammar, so the signer must be visible from the waist up, exposing their face. Protecting privacy and preventing video misuse are paramount. Overall, the creators of SL1 technology must be committed to integrating these cultural considerations into their development processes, ensuring that it aligns with ASL linguistic principles and respects the cultural practices of the Deaf Community.

2.3 Surveys in ASL

One application of SL1 technology is the development of survey tools for the Deaf Community. SL1 technology has no guidelines to follow when it comes to user interface design, as opposed to other languages which have well-developed and documented principles. Since user interface paradigms for signed languages are relatively uncharted territory, it is of utmost importance that researchers have the ability to survey members of the Deaf Community to get their opinions on user experience.

For example, one group of researchers wanted to address the lack of standardized usability questionnaires in ASL for deaf individuals, particularly within the field of HCI (Berke et al., 2019). To accomplish this task, these researchers translated established usability questionnaires, such as the System Usability Scale (SUS) and Net Promoter Score (NPS), into ASL. This translation effort places a significant emphasis on ensuring the psychometric validity of these ASL translations, thus encouraging greater participation of the Deaf Community in HCI

research. While this is a great effort in translating and validating content in ASL, this research did not look into the design of an actual survey itself. Much of the research related to ASL in surveys has been focused on translating, rather than how the information is designed, presented, and delivered to its users. Researchers often rely on design standards that are for written languages because they already exist. There is a significant lack of design principles in place for SL1 technology, emphasizing the need for research in this field and continuous collaboration with the Deaf Community during development.

A notable contribution in the field of SL1 survey tools came from a group of researchers who created a mobile survey application to collect data from sign language speakers (Henney & Chininthorn, 2021). Unlike the translation study, this mobile survey started thinking about how the user interface design of the survey tool itself could more beneficially present the survey information to its users. Though these researchers were specifically focused on creating a low-cost solution for surveying the South African Sign Language community, their research underscores the importance of focusing on and developing design standards for visual language instead of simply translating the survey into signed videos and using text-based design standards to present them on the interface. As was found, text-based surveys often prove less effective for deaf individuals who may be forced to read and respond in their second language. Having a friendly user interface that is designed for sign language speakers allows them to respond more comfortably and fully in their native language.

Similarly, a group of researchers in Barcelona found that the format and layout of questionnaires with sign language videos are critical in their ability to provide an accessible experience similar to that of a text-based survey (Bosch-Baliarda et al., 2019). In contrast to our objectives, the team opted for a universal design, incorporating both sign language videos and

their corresponding text-based translations. While this approach enhanced accessibility for the Deaf Community, it posed limitations for deriving novel design principles specific to SL1 technology since many users stated that they relied on both the text-based and the signed videos for better understanding. Despite this difference, the study identified beneficial features, including consolidating videos onto one screen, placing question videos above answers, and allowing users to click on videos to select answers. Visual feedback, like highlighting selected answer videos with a blue border and a “skimming” option for automatic playback, proved helpful for users when double-checking their answers. However, there were some technical issues encountered such as the server not saving responses and various cost and time limitations. In conclusion, this study started to explore some crucial design elements for SL1 technology, though several challenges in usability and technical implementation warrant further consideration for future improvements.

SL1 survey tools create a user-friendly and inclusive environment, ultimately enhancing the engagement of the Deaf Community in research studies and beyond. The full, unrestrained participation of ASL signers in the creation of SL1 technology is vital to developing tools that are useful for the Deaf Community and creating a better technological experience for signers. By collecting information on user experience and opinions in someone's native language, we can ensure that the data is accurate and information does not get lost in translation.

3 Related Work

3.1 Initial Research into ASL Surveys

In the earlier days of learning about ASL-centric survey tools, a research team at WPI worked on finding the requirements for this type of survey and documenting the challenges associated with this new type of technology (Santacreu, 2021). This team used Qualtrics as the questionnaire platform because of its ability to embed videos, the variety of question types it provided, and its tools for response analysis. They used five question types – multiple choice, multiple select, scalar, hotspot, and matrix. Through iterative design and review from experts at the AEC, the team created a survey design. Figures 2 through 6 show the format for each of the different question types. Using these designs in a sample survey, they conducted a modified think-aloud study to test its usability.

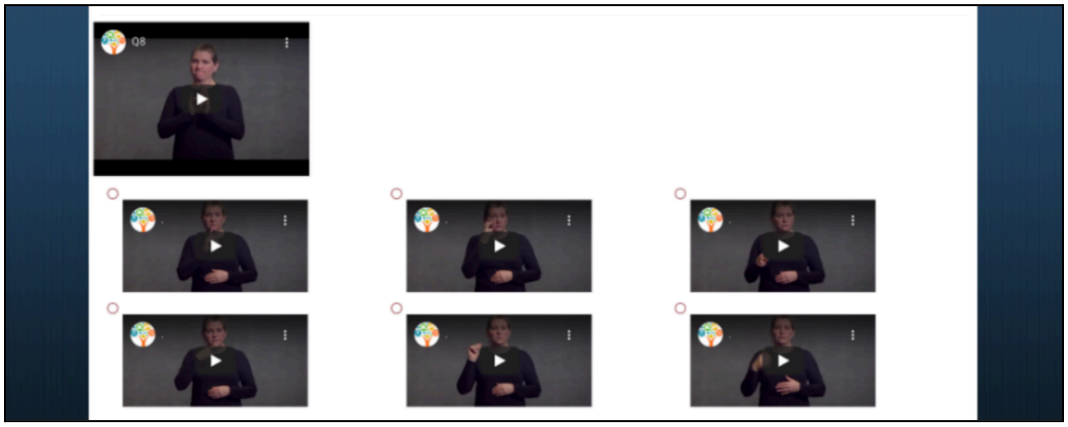

Figure 2 - Qualtrics Multiple Choice Question

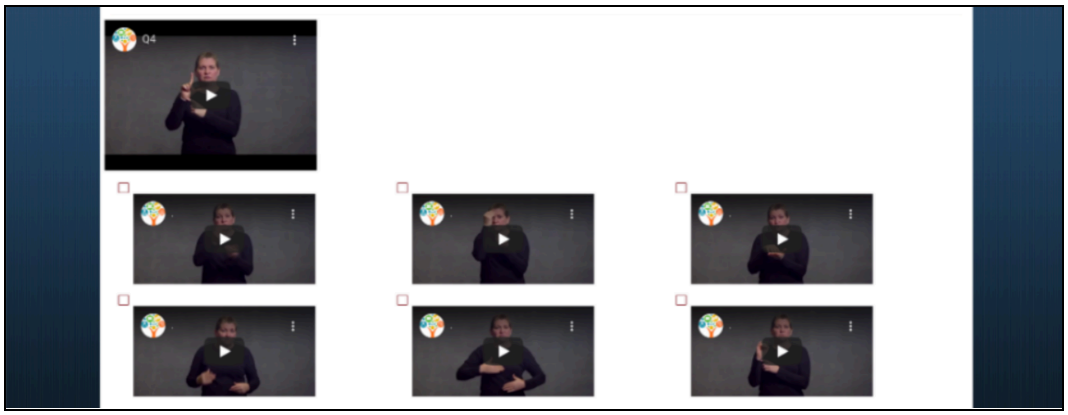

Figure 3 - Qualtrics Multiple Select Question

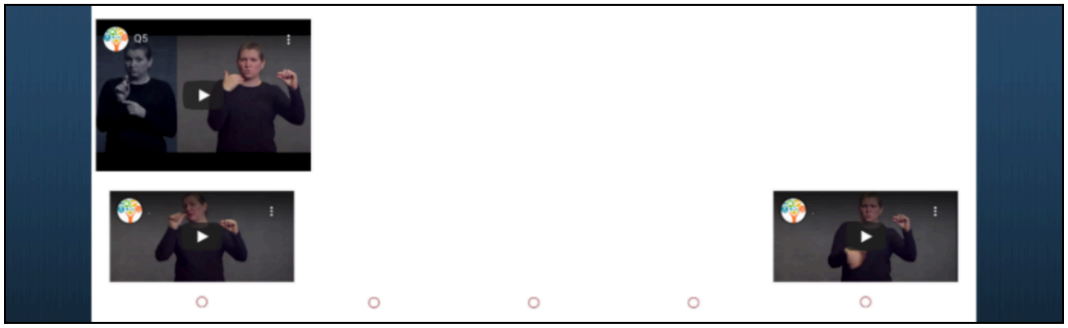

Figure 4 - Qualtrics Scalar Question

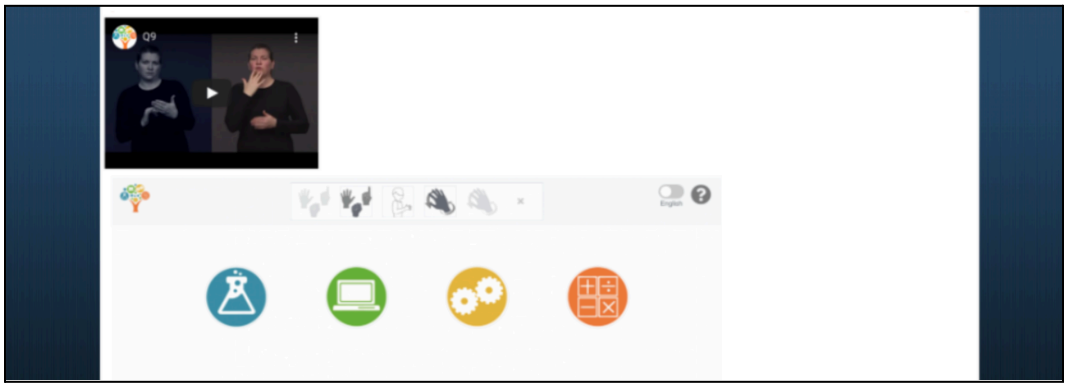

Figure 5 - Qualtrics Hotspot Question

Figure 6 - Qualtrics Matrix Question

Multiple select and multiple choice questions were generally easy to use and did not have significant issues. On the other hand, the matrix questions were problematic because they were very large, even with the dimensions being limited. The sheer number of videos to watch created user frustration. Scalar questions were confusing because the videos were only on the ends of the scale, leaving uncertainty as to what the middle options represented. The hotspot question, which involved recording where clicks were located on the page, was also very confusing since there was no clear explanation of what could be clicked. The matrix and hotspot questions were found to be suboptimal for an ASL-centric survey.

The challenges faced using Qualtrics contributed constructively to the refinement of the survey design. These obstacles provided valuable insights that facilitated the identification and implementation of more optimal question types, such as multiple choice, multiple select, and scalar questions. This was the foundation of the work in future ASL-centric survey designs.

3.2 Survey Tool Designing and Prototyping

After identifying the lack of tools that have both a good user interface and proper functionality for creating surveys with only videos, it was clear that a different piece of software would need to be used for making an ASL-based survey. The next WPI team that worked on this project used Adobe XD for prototyping. They aimed to create an ASL-centric survey tool with multiple choice, multiple select, and scalar questions (Cordova and Henriques, 2022). Their research included the structure of the ASL language, existing ASL-centric surveys, and the distinct features of ASL-centric user interfaces. With this information, they created low-fidelity and high-fidelity prototypes of each question type. The high-fidelity prototypes were regularly shared with the AEC team, allowing the research team to iterate on previous designs based on the feedback they received.

After creating usable prototypes, the researchers conducted a moderated user study with seven participants from the Deaf Community (Cordova and Henriques, 2022). Each participant answered questions using the survey tool and then was interviewed about their experience. There were multiple prototypes for each question type, which allowed the researchers to collect feedback on several design aspects. Figures 7 through 12 are the designs included in this study.

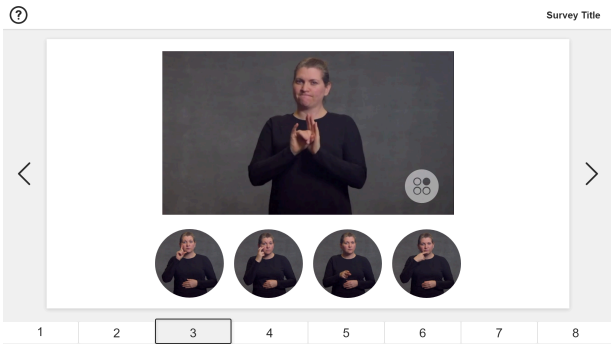

Figure 7 - Prototype 1 for Multiple Choice

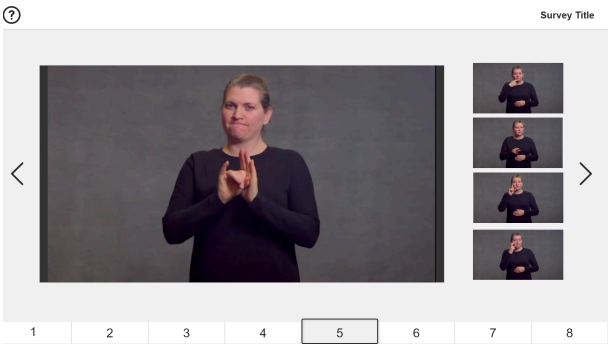

Figure 8 - Prototype 2 for Multiple Choice

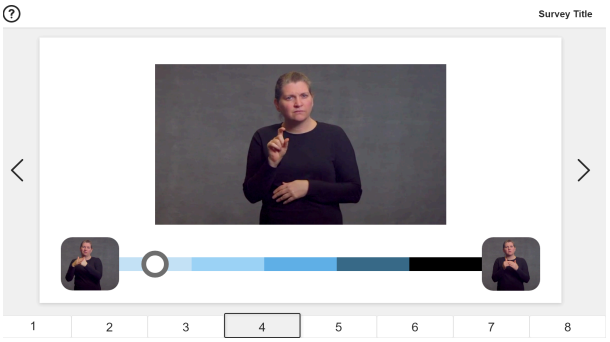

Figure 9 - Prototype 1 for Scalar

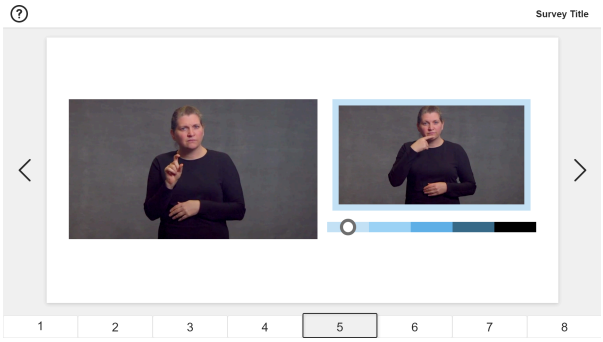

Figure 10 - Prototype 2 for Scalar

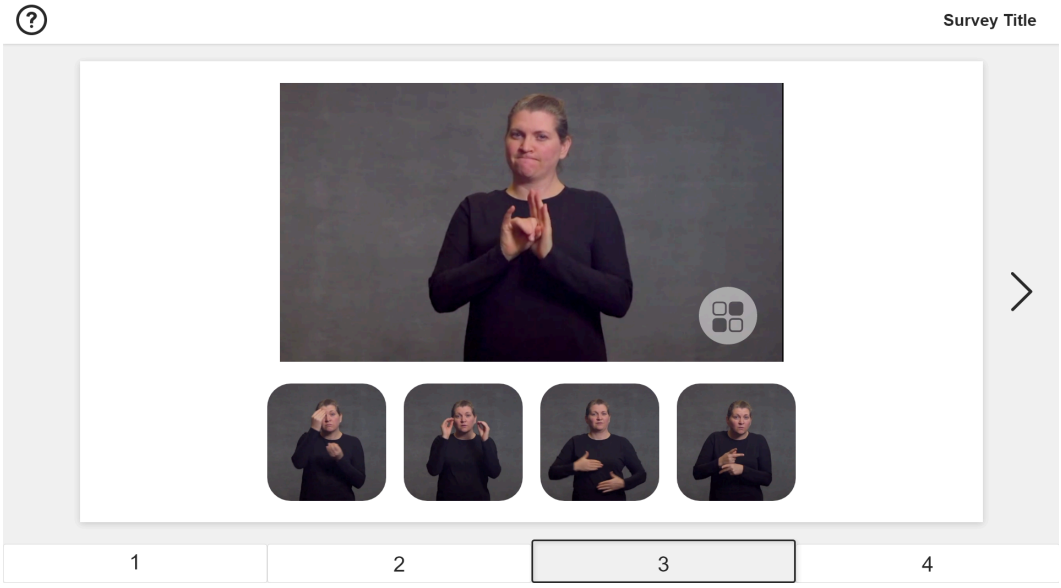

Figure 11 - Prototype for Multiple Select

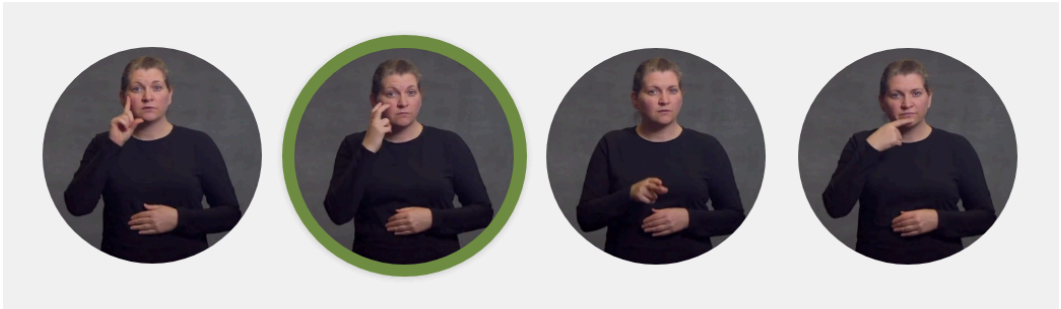

Figure 12 - Prototype for Answer Selection

Based on the insights gathered from these user studies, the research team identified elements of the design that met their objectives. Participants liked the feedback of having a green border around selected answer choices. They also found that when videos had rounded edges, it created a more friendly user experience. One participant pointed out that having answer choices below the question for multiple choice and multiple select questions was better for page scanning the overall flow. For scalar questions, all participants preferred the answer choice video and the scale to be to the right side of the question. The participants also liked that there was a video for each level of the scale and preferred the circle selector to start on the left side of the scale. Participants liked having thumbnails on videos and were satisfied with video speed.

Conversely, the research team also recognized elements of design that did not meet their objectives and could use improvement through redesign. Video sizes were too small, which made it difficult to complete the survey. Some participants ignored or did not notice the navigation bar at the bottom of the screen and preferred to use the arrows to go between questions. Participants who did use the navigation bar thought it was helpful but felt it would be useful to add colors to indicate completed and skipped questions. The prototype also attempted to indicate the question type with the shape of the answer choices and an icon in the bottom-right corner of the question, but both of these visual cues were not received. Overall, the identification of the question type was not very clear. The icons were also found to be distracting from the question video since it was overlaid on top of it.

All participants agreed that ASL-centric digital tools are needed and they felt significant pride in being able to help the Deaf Community. They were incredibly happy to see progress with SL1 technology and felt empowered through their usage of the tool. The feedback from these user studies was the primary driving force behind our research and development.

The research team encountered significant challenges while using Adobe XD to develop and test the survey prototype. A notable limitation was the constraint of a maximum of 20 videos per project, significantly restricting the size of a survey. Additionally, there were inconsistencies with the hover-play functionality. To address these constraints, the project transitioned to developing a new survey tool and defining a minimum viable product (MVP). This strategic shift allowed the researchers not only to have comprehensive control over functionality and features but also facilitated the refinement of the tool based on user feedback and evolving requirements.

3.3 Continued Survey Tool Implementation

Work towards this MVP began shortly after with a new group of WPI researchers. Their first step was the database design, as seen in the Entity Relationship Diagram in Figure 13. From this, the schema was created with PostgreSQL as the database management system.

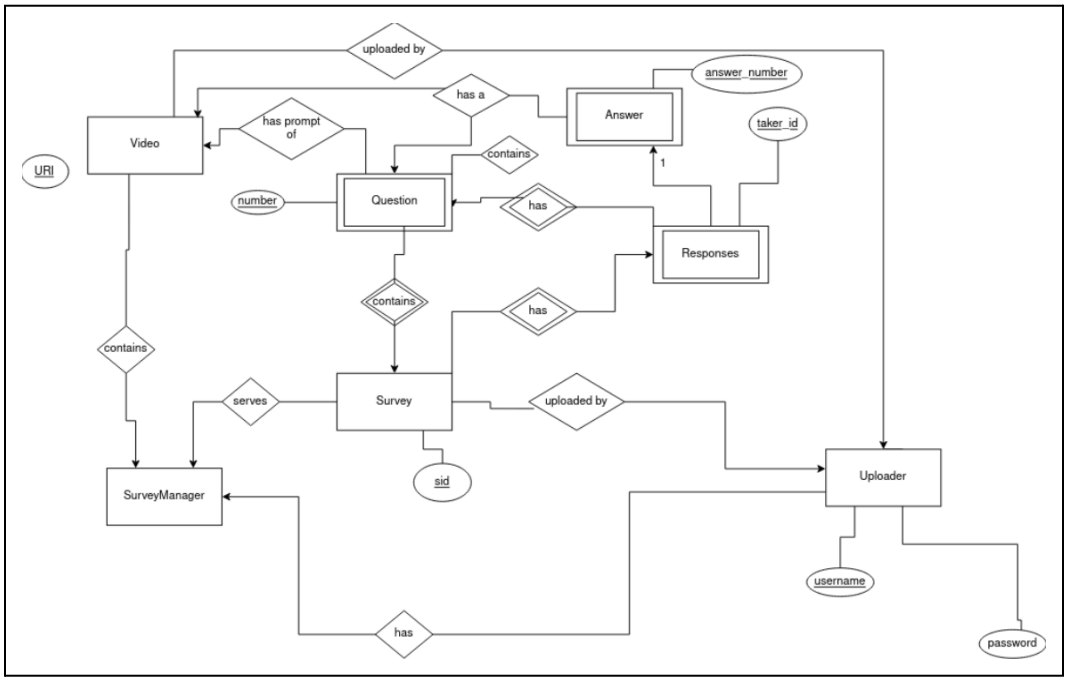

Figure 13 - Entity Relationship Diagram

This MVP supported basic functionality for both survey creators and takers. Survey creators were able to make a new survey and add questions, view survey responses, and open an existing survey. A survey could have multiple choice, multiple select, and scalar questions. Figure 14 shows the survey creator's view of the tool. They could upload videos from their file system for the questions and answers, along with making an English name for the survey itself.

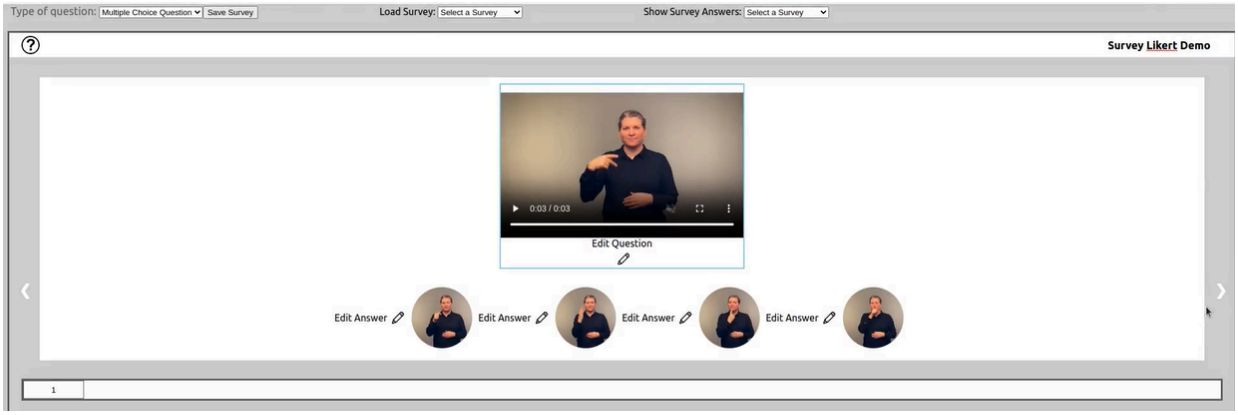

Figure 14 - Prototype for Creating a Multiple Choice Question

Survey takers were able to play question videos and answer videos, answer each question type, navigate between questions, and submit a completed survey. Multiple choice and multiple select questions visually looked the same, with the only difference being that multiple select allowed for picking more than one answer choice. The layout for both of these questions is shown in Figure 15, which also has one of the answer choices selected. The question videos would auto-play and the answer choice videos would play when hovered over. Selected answer choices had a green border around them. Figure 16 shows the page for a scalar question. For this question type, the selector defaulted to the left side and could be dragged along the scale. Each level of the scale played a separate video.

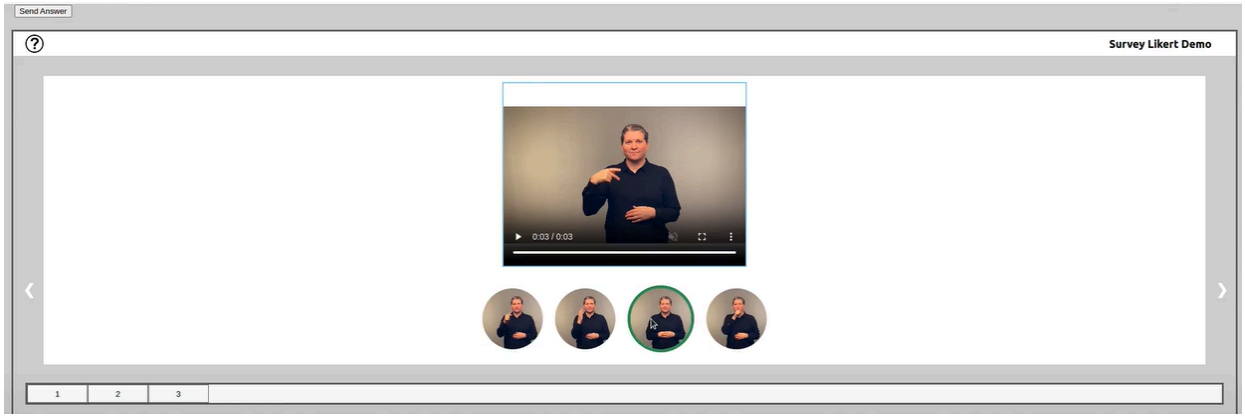

Figure 15 - Prototype for Answering a Multiple Choice or Multiple Select Question

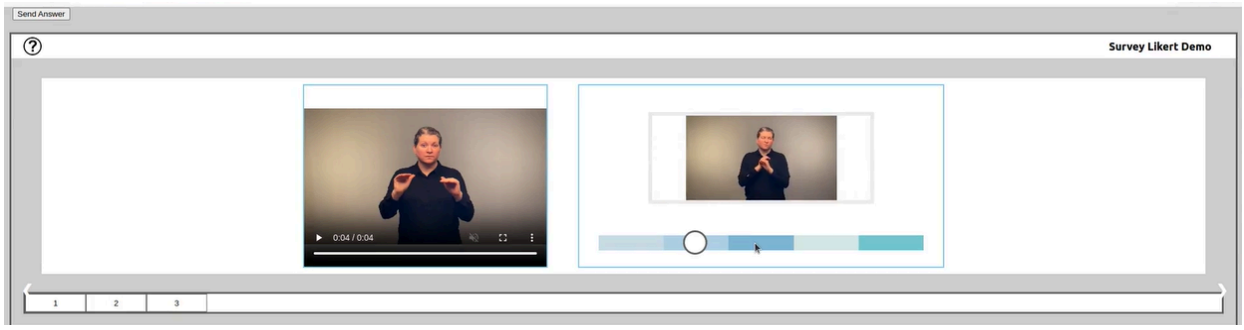

Figure 16 - Prototype for Answering a Scalar Question

This was the state of the survey tool at the start of our project. While this application had many working features, a handful of basic functionality issues needed to be addressed. To point out a few examples, there was no ability to deselect a selected answer choice for any question type. There was visually no difference between watching an answer video and selecting a scale level as the answer, creating inconsistencies with the usage of the hover-play functionality. The navigation arrows on the sides of the page would often overlay onto other parts of the screen, rendering them difficult to see and non-functional. The functionality of the arrows themselves was also often inconsistent when using both the navigation bar and the arrows.

There were also several visual differences in this version of the survey tool, in comparison to the prototypes from the previous user study. This is most noticeable when looking at the videos themselves. For instance, the aspect ratio of the question video was not the same as the container it was located in, making it appear improperly placed on the screen. The spacing was also inconsistent. In particular, when an answer choice was selected and a green border was added, the other answer choices would shift horizontally due to the extra width. The answer choice video in a scalar question was significantly smaller than the question video, creating usability concerns. Additionally, the application was still reliant on English from the perspective of a survey taker, with the “Submit Answers” button being used to submit the survey and the name of the survey shown in the top right. With the number of inconsistencies and lack of internal documentation, it was clear that the survey taker's perspective of the application, what we were aiming to focus on, was still a work in progress at the time it was given to us.

Even though there were many complications with the front-end of the application, this prototype was still a great start to having a functional ASL-based survey tool. The back-end of the application worked well for uploading survey media, saving it to a specified cloud storage location, and accessing a survey with a link corresponding to the survey name. Most of these tests were done hosting the application locally, but there was also progress made towards hosting it on a server. The survey tool also allowed the survey creator to look at metrics for the surveys, including both individual responses and a summary of the results. Though there was lots of work to be done, the project that we were provided was a good foundation for our development.

3.4 Contributions from the ASL Education Center

Researchers at the ASL Education Center (AEC) were our primary collaborators in the Deaf Community who provided insight into the design and features of our survey tool. They have been involved in the project since its inception, along with developing other related work, such as ASL Clear (Reis et al., 2015). Their partnership has been incredibly valuable to our research and development process, as we have had a steady stream of feedback from individuals who are invested in the survey tool and are part of our target user demographic.

Our AEC collaborators made their own Figma design in the initial stages of creating the survey tool, as seen in Figure 17. Since there were significant differences between the layout and appearance of each previous prototype, this design was shared with us for additional clarity on the end goal. This prototype showed the application open in full-screen mode with the questions and answer choices taking up the entirety of the page. While the actual application was not to be designed for full-screen usage, seeing the minimalistic design gave great insight into the importance of a clean and uncluttered layout for ensuring the usability of the tool.

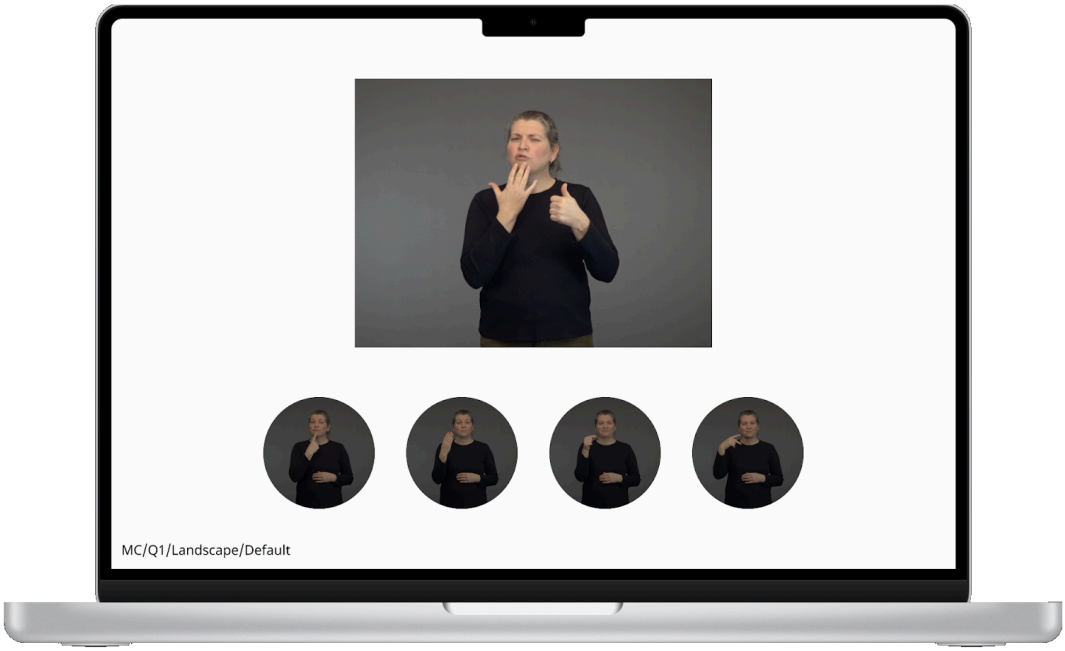

Figure 17 - AEC Figma Design for Page Layout

The AEC researchers also had their own set of research questions based on their interests in the application. For example, they wanted to learn more about how users feel about various effects on buttons, such as borders, color indicators, and zoom animations. These effects help differentiate a non-interactive image with an interactive video for answer choice buttons as well as showing their current status. Some of these ideas for multiple choice question answers are shown in Figures 18 and 19. These design concepts were also applied to multiple select questions, instead with a square-shaped answer choice as opposed to a circle.

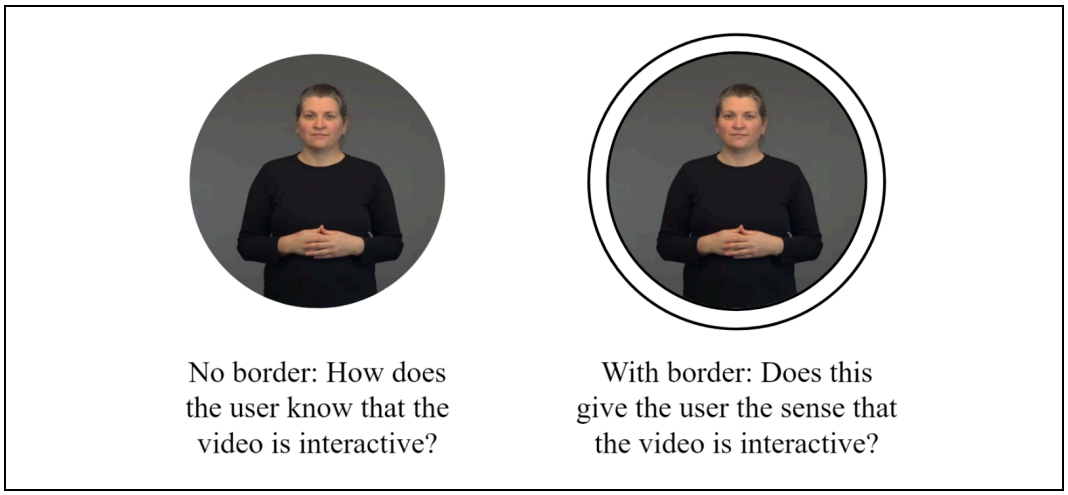

Figure 18 - AEC Idea for Showing Button Interactivity

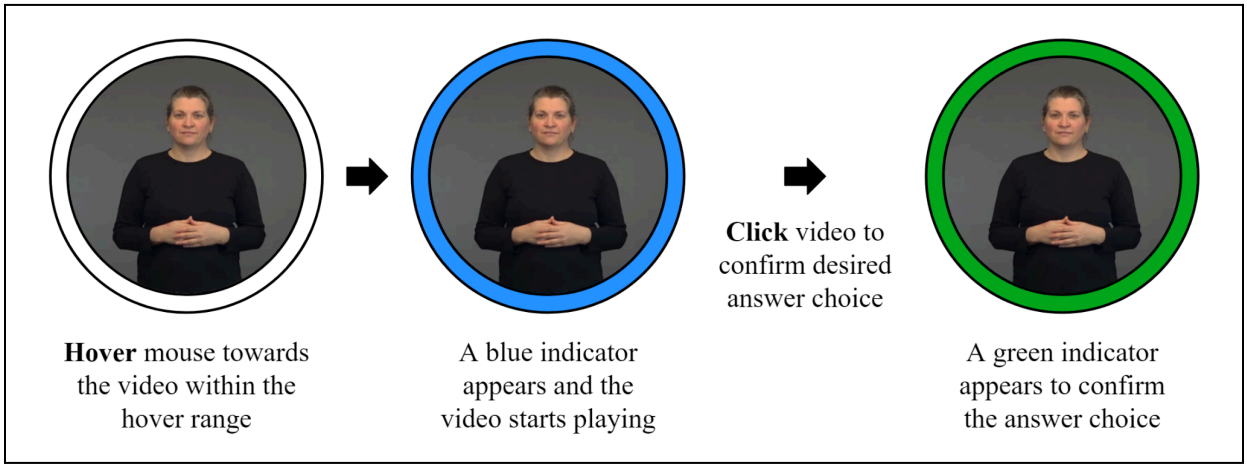

Figure 19 - AEC Idea for Button Indicators

They were also interested in researching the location of the navigation bar and determining what information should be displayed. This information could include question numbers, the current question being viewed, and the status of each question as answered or unanswered. This concept was similar to one of the ideas proposed in the previous research study but had never been further investigated by any research team.

Our partners at the AEC also had many ideas for the design of scalar questions, especially since this was not as far in development as the other two question types. Many of their concepts for scalar answer choices were similar to those for multiple choice and multiple select answer choices. For example, they wanted to see the scale level buttons with a black outline to look like a radio button (Figure 20), and blue and green colors to indicate the state (Figure 21). However, they had several ideas for the color indicators, as seen in the options in Figure 21.

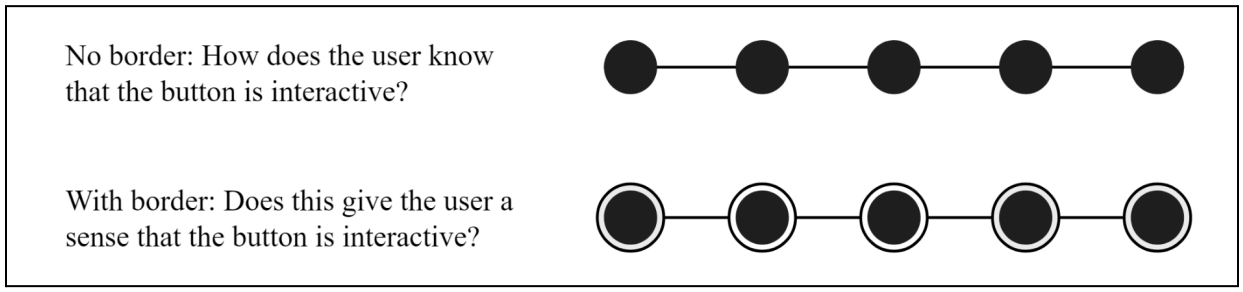

Figure 20 - AEC Idea for Showing Scale Level Button Interactivity

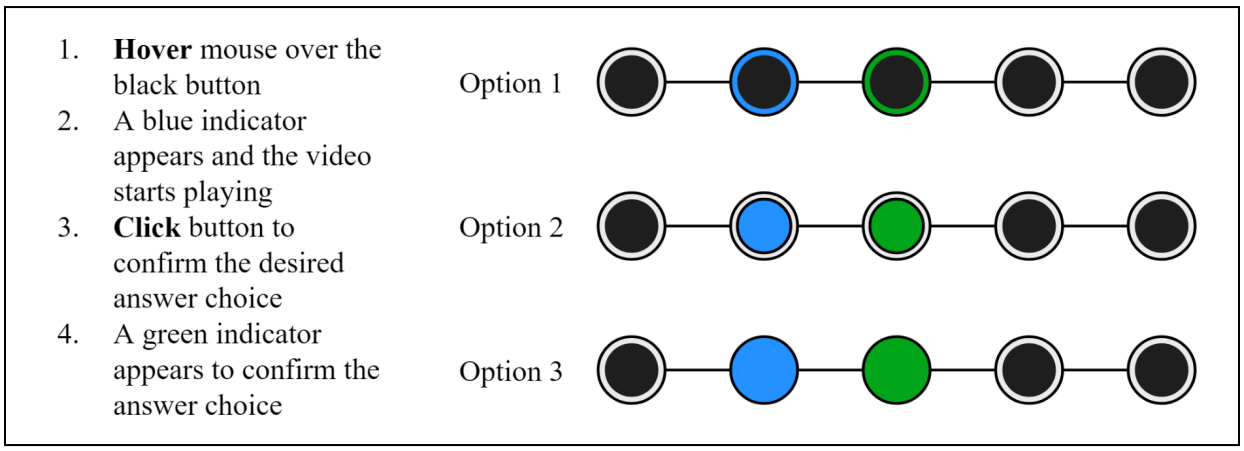

Figure 21 - AEC Ideas for Scale Level Button Color Indicators

Overall, while we had our own research questions, we incorporated many of the design ideas from the AEC into our final implementation. Research studies about specific features are opportunities for future work through the continued iteration of the survey tool design.

The researchers within the AEC conducted independent feature testing to determine proper video sizing and spacing specifications for the application with a minimum 14-inch screen. This included the default size for the question video, along with rounding the corners of the video. For multiple choice and multiple select answer choices, there were also minimum size specifications. Additionally, they detailed the width of the color indicator borders and how wide the hover zone outside of the question video should be to limit hover delay. Multiple choice answer choices were to be circles, while multiple select answer choices were to be squares with rounded corners. Their specifications also included a minimum size for the scalar level buttons and space between various page elements.

There was also documentation of what colors should be used throughout the application to be in accordance with the Web Content Accessibility Guidelines (WCAG) and U.S. Web Design System (USWDS) system colors. These colors meet requirements for non-text contrast to account for red-green, blue-green, yellow-red, and complete color blindness (*WCAG 2.2*, 2023). The system colors selected also follow USWDS component standards for states and alerts (*Using Color*, n.d.). Per these standards, the AEC chose specific color codes for the blue and green indicators, along with the background color of the survey. With the input and ideas provided by the AEC, we proceeded to plan the features we would implement and enhance during the iteration of our project development.

4 Project Goals

4.1 Stakeholder Analysis

Upon receiving the survey tool in its initial MVP iteration, our first strategic move involved conducting a stakeholder analysis to effectively guide our development efforts. Given the multifaceted purpose of the application, there were two main stakeholder groups to consider. The primary group consisted of users *taking* a survey, which included members of the Deaf Community who use ASL. The secondary group consisted of users *creating* a survey, specifically researchers of SL1 technology. This includes members of the Deaf Community, ASL-signing experts, and hearing designers who collaborate directly with these groups. This approach allowed us to prioritize application requirements, addressing gaps in the existence of SL1 technology from multiple perspectives.

4.1.1 Deaf Community Members

As previously mentioned, members of the Deaf Community who use ASL served as the primary user group for our application, playing a crucial role in our decision-making process and evaluating the success of our survey tool. With the lack of SL1 technology in existence, the continued development of this application was a step in the right direction of expanding user interfaces that are accessible in ASL. Offering the Deaf Community the option to take surveys in their preferred language allows them to effectively participate in a broader range of user studies. For example, they could be a participant in a usability study for another piece of SL1 technology and be able to interact with a questionnaire about that technology more comfortably. This approach would allow for direct feedback in ASL from potential users to facilitate the growth of future SL1 technology.

4.1.2 SL1 Technology Researchers

While researchers who study SL1 technology were not necessarily the primary stakeholders of our project, they benefit from being able to create an ASL-centric survey and hence are invested in our success. Their overarching research goal is to design and develop tools specifically for usage in ASL. For this iteration of the project, we specifically worked with SL1 technology researchers from the WPI HCI Lab and the AEC. The preferences and feedback of the Deaf Community are invaluable to SL1 technology research, which is why they should be given the opportunity to participate in research using their first language. The creation of this survey tool would allow researchers to distribute unmoderated studies and reach a larger pool of potential users without needing an ASL interpreter to run each test.

4.2 Application Requirements

After conducting our stakeholder analysis, we realized that our application had a wide range of requirements for each of these groups individually. Survey takers from the Deaf Community were more interested in the front-end user interface design and functionality of the application, while SL1 technology researchers wanted robust back-end features to be able to conduct thorough research. To account for both groups, we curated a list of application requirements divided into two groups: user interface and functionality.

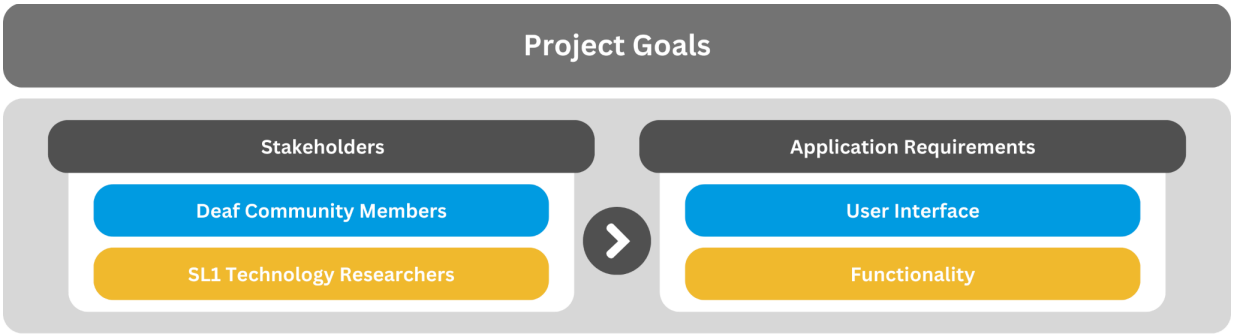

Figure 22 - ASL Survey Tool Project Goals

4.2.1 User Interface Requirements

As the Deaf Community was identified as our primary user group, it was important to put our main focus on the front-end user interface requirements for user-centric development. Combining the findings from previous research studies and input from our AEC collaborators, we identified a list of these user interface requirements (Appendix A). These requirements were divided into five categories: sizing and spacing, system colors, color indicators, application layout, and the hover-play functionality.

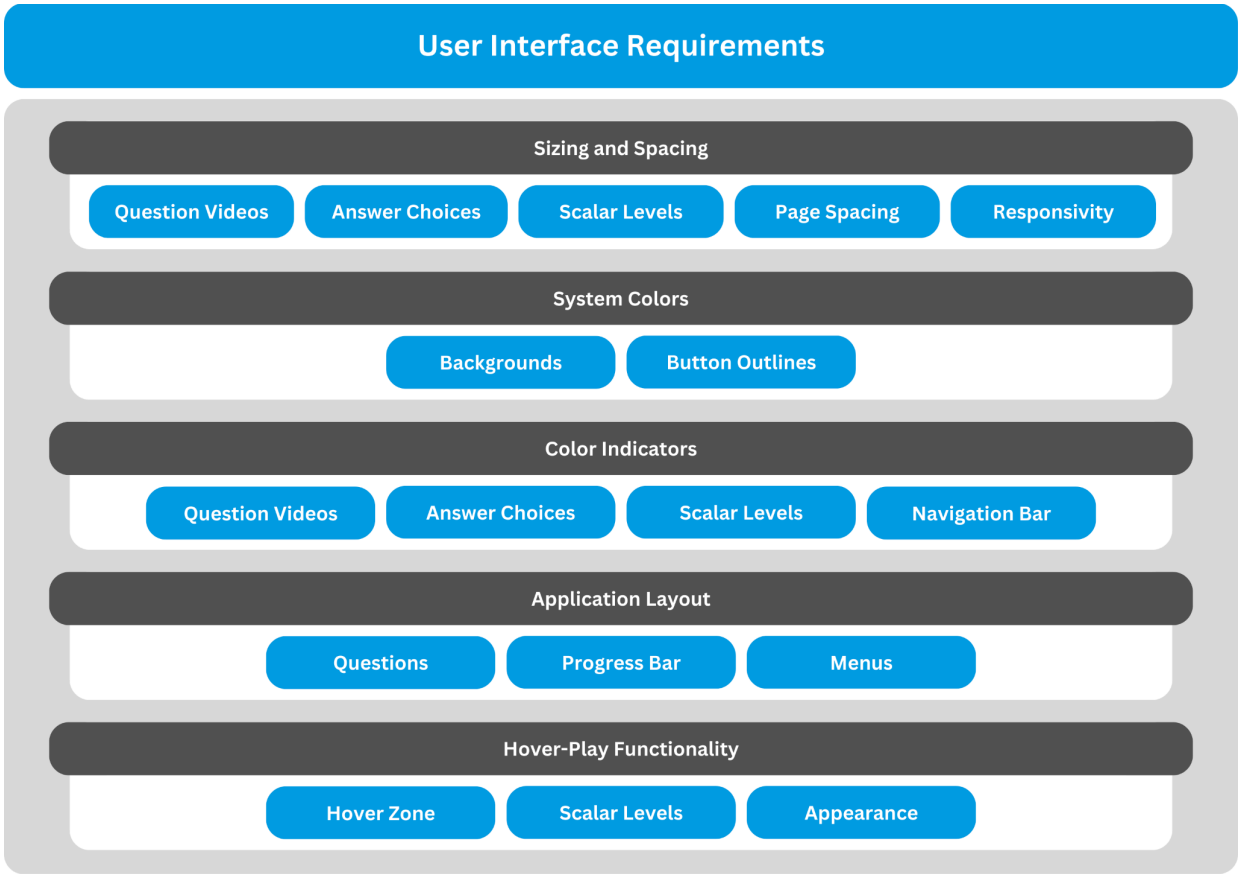

Figure 23 - Overview of User Interface Requirements

Our first group of requirements was focused on the sizing and spacing of various user interface components. One example was making sure all videos were big enough for the user to view the signer within the answer choice circles. These requirements were identified by the AEC for implementation in the MVP. Other sizing and spacing requirements included spacing between answer choice hover zones, and using responsive design for various screen sizes.

The second and third groups of requirements involved colors within the system and how they were implemented. There were specific colors for the background (gray and white), along with indicated hovered or “active” elements (blue) and selected elements (green). These specifications were chosen by the AEC based on the WCAG and USWDS system colors.

Our fourth group of requirements focused on the overall layout of the application. This included having the answers located below the question for multiple choice and multiple select questions and having them on the side for scalar questions. All of these requirements came from the results of previous studies.

Lastly, our fifth group of requirements focused on the hover-play functionality, in which a user can hover over an element to trigger a video to play. This user interface component was of significant interest to the AEC, especially where the hover-zone was in relation to an answer choice. Additionally, this included the visual distinctions between a video that is being hovered over and one that is not.

4.2.2 Functionality Requirements

Moving on to our secondary stakeholders, the needs of SL1 technology researchers were more in line with the back-end functionality requirements. Some of these requirements were curated from findings from the past research study; however, most were ideated through the creation of the MVP and discussions with the WPI HCI Lab and the AEC teams. These ideas were meant to identify functional needs of the application such as keeping costs low for media storage and identifying metric data that is valuable for the tool. Combining these ideas, we created a list of functionality requirements (Appendix B). These requirements fell into two categories: the Minimal Viable Product (MVP) and additional back-end features.

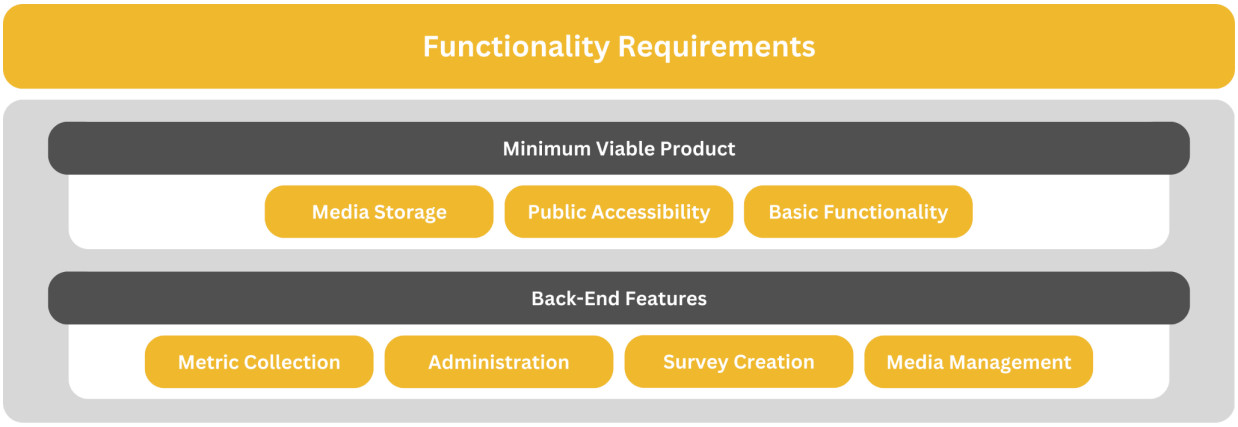

Figure 24 - Overview of Functionality Requirements

The first goal was to create a fully functional MVP. To accomplish this, we would need to use cloud media storage for videos, make the application accessible to users via a link, and ensure that all basic functionalities such as viewing media, selecting options, and submitting responses worked. The original setup had users running the application locally, using their own S3 bucket for video storage. To reach our goal, we needed to create an administrator IAM role and S3 bucket controlled by this administrator and then connect the bucket to the survey tool. We also set up the application on a WPI server to make it public. For the basic functionality, much was already implemented; however, thorough testing needed to be done to identify any issues.

Our second goal was to add additional back-end features if time allowed, related to data collection and administrative capabilities. This included data on how a user interacts with the application, such as timestamps and clicks, to be used for analysis in future research opportunities with the tool. The administrative capabilities were items such as the ability to delete an existing survey, upload a thumbnail image, and browse videos already uploaded to the S3 bucket for reuse.

Since we were focused on our primary stakeholders, we chose not to prioritize the back-end items because they mainly benefit our secondary stakeholders. However, we still considered these to be important to the application and good features to consider in future work.

4.2.3 Prioritizing Requirements

After identifying all requirements, it was clear that we could not accomplish every request within the time allotted for development. To prioritize each user feature, we took into account two categories: priority and time. We first classified each requirement by the amount of time that it would take as high, medium, or low. From here, we identified the priority level, using the same three classifications. We labeled items as high priority if they were vital to the application, medium priority if they were useful but not as important as other items, and low priority if they would have been nice to have but were ultimately fine to not address within our timeline. Using the categories of priority and time, we created a draft of deadlines for each high-priority and medium-priority item. We then discussed each item with the team members from both WPI and the AEC, made revisions, and began the development process.

5 Methodology

5.1 Agile Development

As our survey tool often had frequently changing requirements, we chose a development strategy to satisfy this need. We decided to use Agile Kanban development, as it offers a dynamic and flexible approach to development that could accommodate the evolving needs and priorities of our survey tool (Agile Alliance, 2015). Agile Kanban also focuses on completing tasks before starting new ones, promoting teamwork and communication.

Another benefit of Kanban is its visual workflow (Modi, 2022). Given that we collaborated not only within our team but also with our AEC partners, it was crucial to have a clear and accessible means of displaying the project's current status at any point in time. To accomplish this, we used Trello, a popular project management tool that uses a card-based system to help teams organize their tasks throughout the development process (Warren, n.d.). An example of this visual workflow can be seen in Figure 25. Board columns include Backlog, Acknowledged, Deployment - In Progress, Deployment - Ready, Testing - In Progress, Testing - Ready, Deployment, and Done. Work items, displayed through cards, will move from left to right as they are completed to keep all team members up to date on task completion.

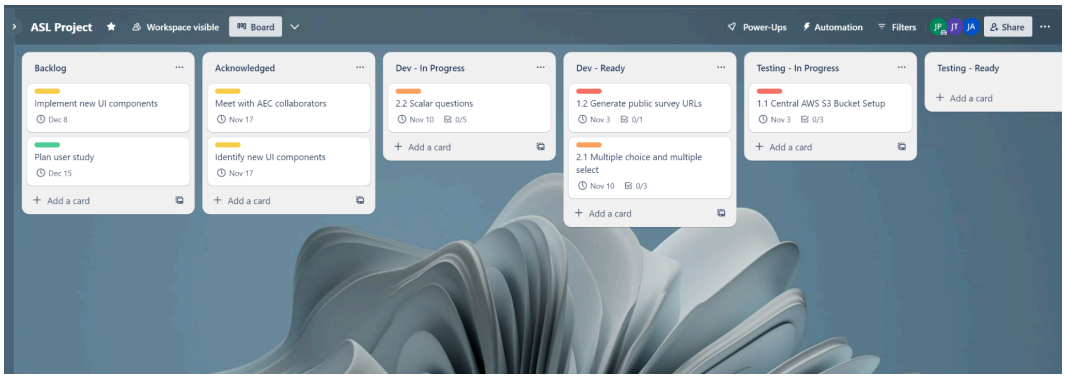

Figure 25 - Trello Board for Agile Kanban Development

5.2 Technology Stack

There are a variety of different technologies used for the software engineering aspect of this project, as seen in Figure 26. Since there were already implemented prototypes in existence, we continued to use HTML, CSS, and JavaScript with React for the application's front-end. HTML is used to organize web pages and their content like text, media, and buttons (*HTML*, 2023). CSS defines the styling and visual appearance of those HTML elements when they are rendered on screen (*CSS*, 2023). Both of these web technologies come together with JavaScript, which enables dynamic content and other complex website features (*What is JavaScript?*, 2023). Using the React library with JavaScript allows for greater capabilities with user interface design without having to focus on the technicalities of rendering (*Getting Started with React*, 2023). React is also extremely useful for its built-in Hooks, especially for storing variable states and synchronizing state changes with external systems (*Built-in React Hooks*, n.d.).

The back-end of the application continued to use the Python web framework Django for scripting purposes, alongside the package manager Conda. A PostgreSQL database will be used to save survey data, and survey media will be stored using an Amazon Web Services (AWS) S3 Bucket. This workflow is similar to most web applications – the user makes a selection on the front-end, such as saving a survey, which then makes an API call to the server that stores survey information in the database and video files in the S3 bucket. To make the application publicly accessible, it was hosted on a WPI-affiliated server.

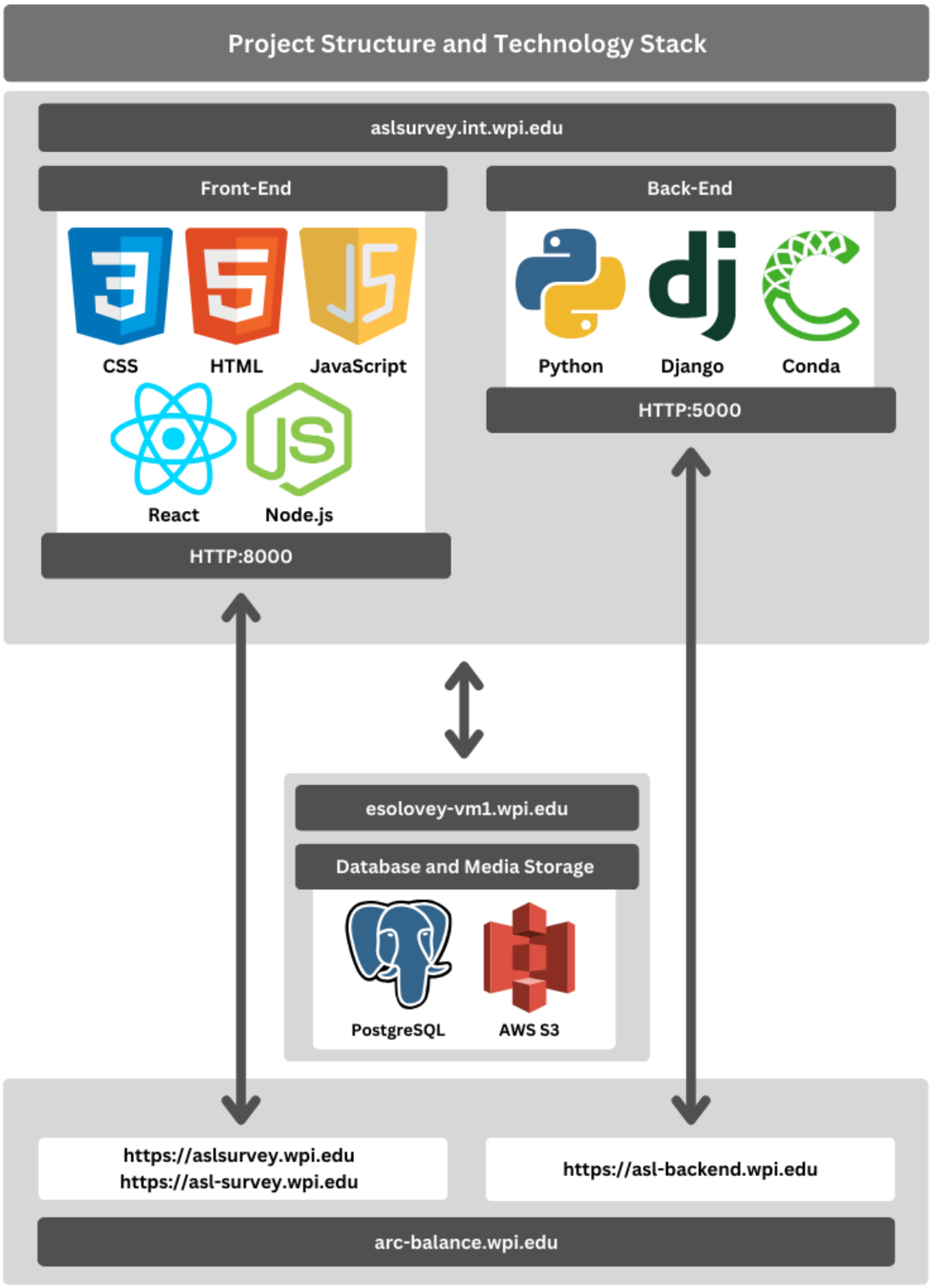

Figure 26 - Project Structure and Technology Stack

We used GitHub for version control throughout the development process. GitHub offers a robust set of tools and practices for effective collaboration and code management. Using branches allowed us to work on implementing new features or bug fixes without affecting the main code base, reducing the risk of confusing different lines of development (*Version Control Best Practices*, n.d.). This also helped with the testing process, because we were able to isolate individual changes to test before doing testing after features were combined into one branch. We had a very structured and transparent approach to incorporating new code to ensure that the quality, consistency, and security of the code met our standards before it was finalized. By using these tools and processes, we were able to adapt to the evolving needs and priorities of our project as well as create a collaborative and efficient work environment. The combination of Agile Kanban, Trello, and GitHub allowed our team to respond easily to change while also ensuring the creation of a dependable end product.

5.3 External Programs

Through the Computing Research Association, we were fortunate enough to be participants in UR2PhD (*UR2PhD*, n.d.), a program whose mission is to get more women and gender-marginalized students involved in undergraduate research. We took a weekly online course for additional mentorship on researching and writing about our project, with particular extra support for our project proposal. Our graduate student advisors were also part of a mentor training program, which helped them develop their skills in supporting students through the research process. Overall, our research team benefited significantly from having this additional support network and guidance.

When creating technology for a community that you are not personally a member of, it is important to have a connection to the target user group. Besides regular communication with our AEC collaborators, each member of the research team also took an introductory ASL class to learn about basic signs and the culture of signed languages. This experience was incredibly important for gaining a practical perspective on the impact of our research.

5.4 Team Meetings

We had several types of meetings each week – ones with just the student team, ones with our HCI Lab advisors, and ones with our advisors and AEC collaborators. These meetings were important for keeping our stakeholders informed. We created a detailed agenda that would be sent out to all participants before every meeting so attendees could preview topics and be prepared with ideas. Each week, we also made a progress report with what each team member worked on, a summary of the previous week's meetings, the accomplishments for the week, and changes in project goals. All of this documentation helped us see the progression of our project over time and make sure we were keeping to a reasonable timeline.

6 Implementation

6.1 Minimum Viable Product

The first part of the survey tool's technical implementation was working on our identified MVP, which included setting up the media storage in AWS, hosting the application on the server, and testing all functionality necessary for having a working survey. Setting up the cloud storage was fairly simple. First, we created an Amazon Simple Storage Service (S3) bucket with a root user belonging to the WPI HCI Lab. Then, we created a user group with the permissions that are required for creating a survey. Next, an administrator IAM role was made and assigned to the user group. Lastly, we connected this S3 bucket to the survey tool, where we were able to upload new survey media and view it successfully.

Our next course of action was to do all of the functionality checks for the survey tool. At this point, we were running the tool locally on our machines, so these tests were offline. We verified that users could view all survey media, answer all question types, navigate between questions, and submit a survey. From the survey creator's perspective, we also verified that responses were saved and could be exported. If any missing functionality was identified (such as deselecting answer choices) they were added during this stage.

The last significant part of our MVP was having a survey accessible on a server so that external users could access the site. This was the most challenging part of the MVP and required coordination with the WPI Academic and Research Computing for the setup process. They had to reset the server due to migration issues, and they also helped us with making our server and database more secure for online deployment. From here, we changed the server settings so that it was accessible outside of WPI, allowing us to send a survey link to an external user and preparing us for user testing.

6.2 Video Shape, Sizing, and Layout

We added default sizing to the question videos, answer choices, and scalar buttons based on the specifications provided by the AEC. All of the video corners that were originally sharp were changed to round, and spacing was defined between page elements. We verified that all layouts were consistent with those chosen for the final design. We moved the “Submit Answers” button to the end of the navigation bar and changed the content of the button to an icon to remove all English text on the screen.

6.3 Colors and Indicators

Another significant area of work for the implementation was with colors. The first part of this was the indicators for question videos, where we made the border black when the video was not playing and blue when playing. This can be seen in Figures 27 and 28, and this design applied to all three question types.

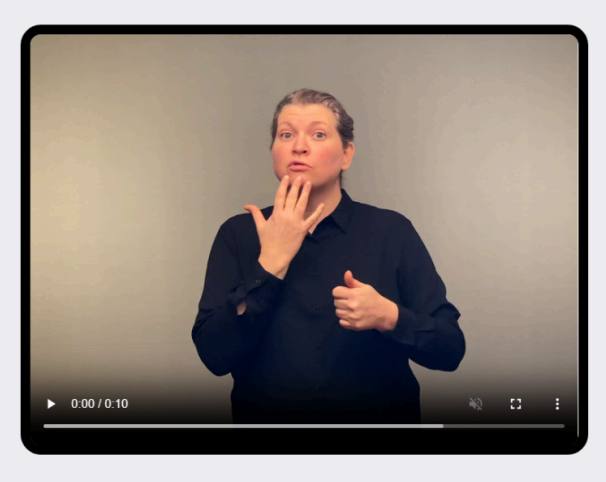

Figure 27 - Question Video Not Playing

Figure 28 - Question Video Playing

The next part was the answer choice color indicators for multiple choice and multiple select questions to provide feedback with the hover-play functionality. We selected three states for an answer choice: inactive, playing, and selected. Figures 29 and 30 show these designs, where an inactive video is desaturated, a playing video is enlarged with a blue border, and a selected video is enlarged with a green border. Looking at these figures, we can also see the difference between these question types in the answer choice shape. This was done to make the design similar to common survey elements, specifically radio buttons and checkboxes. Additionally, the innermost black border was added to separate the color indicator and the video. Our AEC collaborators noted that without this border, the color intruded on the signer's space.

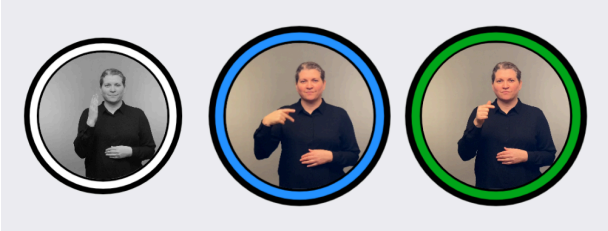

Figure 29 - Answer Choices for a Multiple Choice Question

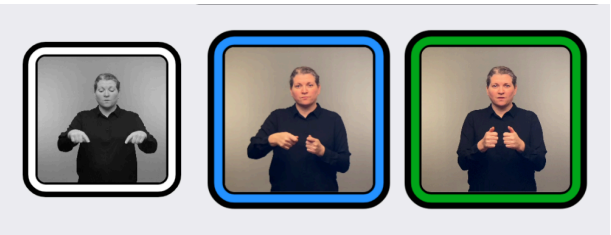

Figure 30 - Answer Choices for a Multiple Select Question

Another type of color indicator was the scalar level buttons. We followed a similar structure with the three states of inactive, playing, and selected. The AEC suggested several options for the design of the buttons, and we ended up using what is shown in Figure 31. In this example, the user has selected Option 3 and is currently hovering on and playing Option 2. When these buttons are hovered on or clicked, the answer video that is displayed above will change to the matching video. We also made the border of the answer choice video the same color as its corresponding button.

Figure 31 - Answer Choice Scale for a Scalar Question

The last color indicator we created was coloring on the navigation bar buttons to represent the state of each question. We used the three states of inactive, active, and answered. A question is active when it is the question that the user is currently viewing and has not been answered, while a question is inactive when it is not the question being viewed and is unanswered. Similar to the other states we implemented, we used white for inactive, blue for active, and green for answered. Figure 32 shows an example of the navigation bar with a five-question survey, where Questions 1 and 2 are answered, Question 3 is active, and Questions 4 and 5 are inactive. This also shows the updated submit button.

Figure 32 - Navigation Bar for a Survey with Five Questions

6.4 Final Application

In summary, we made significant improvements to the survey tool prototype and created a full-fledged online application. Figures 33, 34, and 35 are the final designs of all three question types, showing each question as a part of the entire application page.

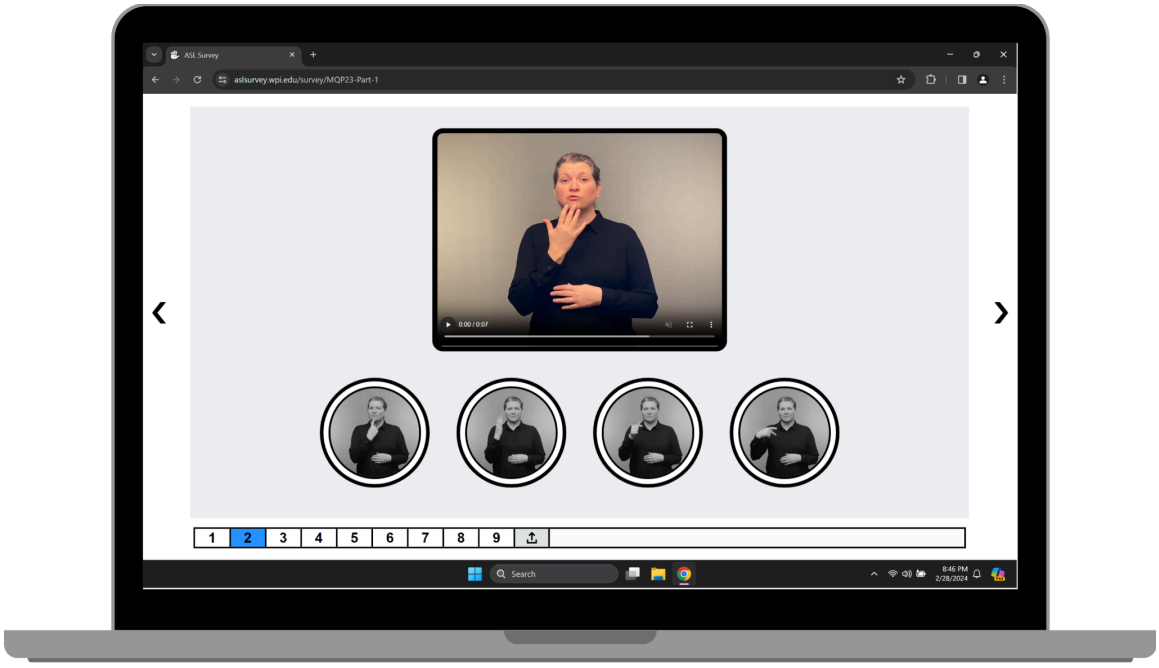

Figure 33 - Final Implementation of a Multiple Choice Question

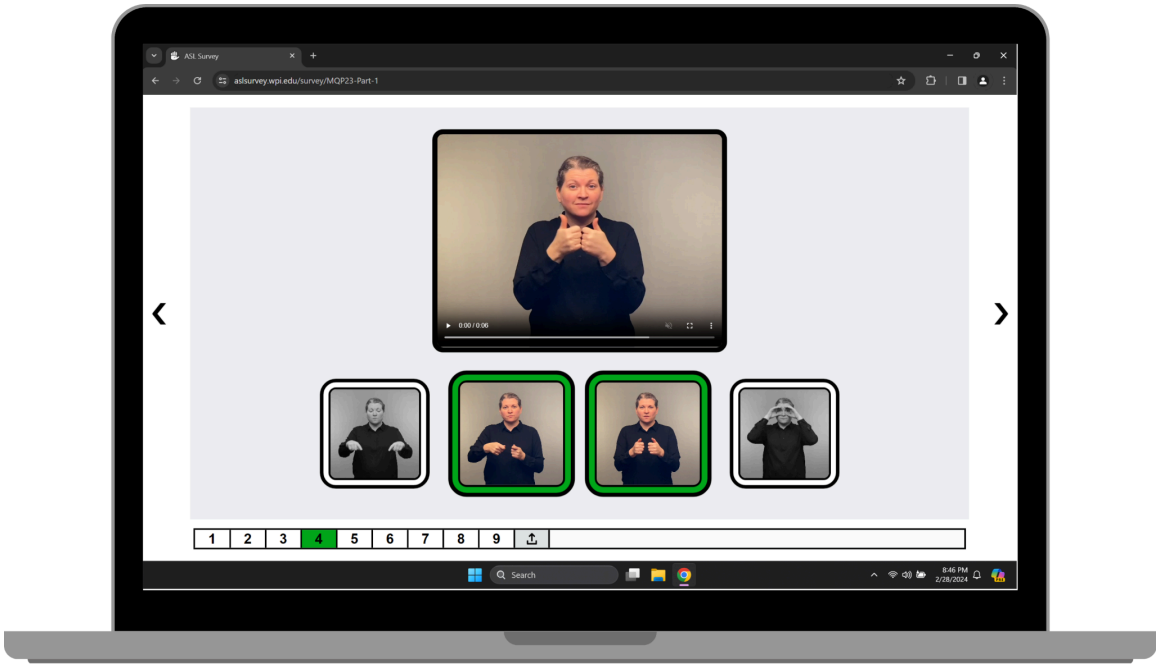

Figure 34 - Final Implementation of a Multiple Select Question

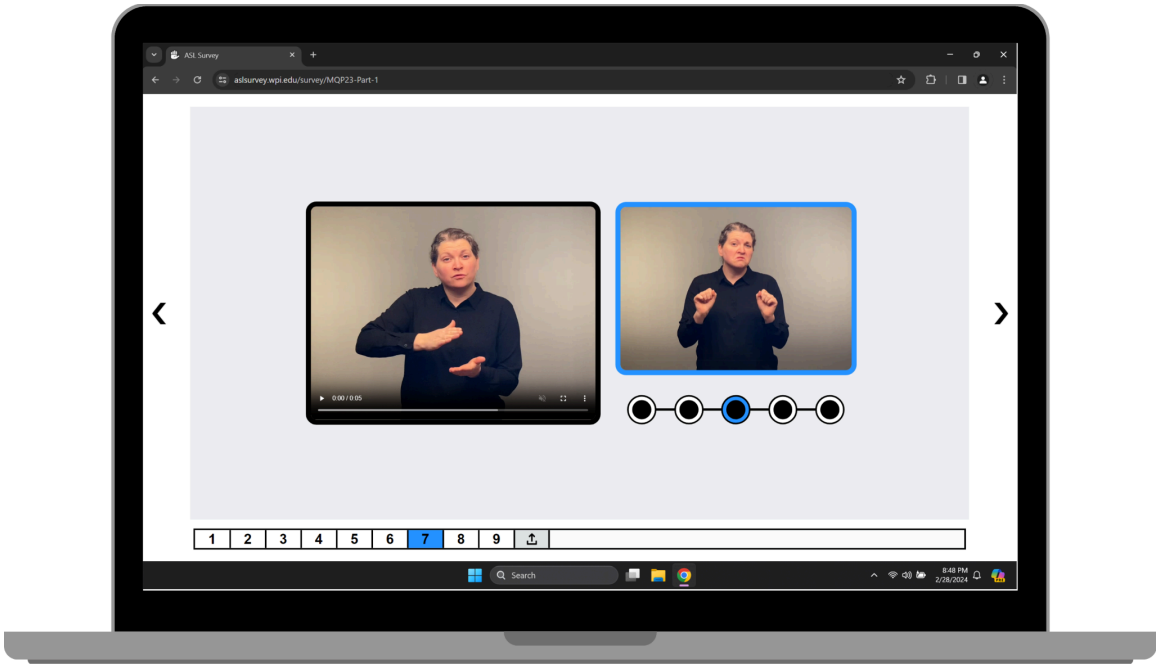

Figure 35 - Final Implementation of a Scalar Question

7 Evaluation

7.1 Evaluation Metrics

To assess our progress through the problem statement, we identified two measures of success for the ASL Survey Tool: application functionality and user experience. To evaluate these measures, we distributed a user study to members of the Deaf Community and collected quantitative data about the usability of the system. This study allowed us to see if the survey tool was functional overall and provided us with direct feedback from survey takers about their user experience. Subsequently, this data was analyzed with the goal of providing insight into the application's usability. With all this information combined, we looked further into the practical usage of the survey tool in an unmoderated user study.

7.1.1 Application Functionality

The first measure of success for the tool was whether or not the survey tool was functional. This related to the technical progress of the tool itself, being evaluated on if:

1. a link to a survey could be sent to and opened by a user,
2. a user could answer survey questions,
3. a user could submit a completed survey,
4. and the data from each submitted survey was saved.

These aspects of functionality were vital to being able to use the tool to distribute a survey online to a wide audience. Having the ability to distribute unmoderated surveys to the Deaf Community is an important part of equitable research methodologies when creating SL1 technology.

7.1.2 User Experience

The second measure of success for the tool was the experience of the user while taking a survey, which was evaluated by looking at the usability of the application overall. This was done using the System Usability Scale (SUS), which is an industry-standard method for technology evaluation (System Usability Scale, 2013). It involves a list of ten statements related to the usability of a system, and respondents score how much they agree or disagree with each statement. The ten questions alternate in style, with all odd-numbered questions positively worded and all even-numbered questions negatively worded. This means that the goal for odd-numbered questions is to have answers of "Agree" or "Strongly Agree," while the goal for even-numbered questions is to have answers of "Disagree" or "Strongly Disagree." These responses are then converted to points and combined with a rubric to calculate a score from 0 to 100, with higher scores indicating a more usable product.

7.2 User Testing

To carry out our evaluation of the ASL Survey Tool, we conducted user testing with the survey tool on members of the Deaf Community. With our emphasis on usability and the overall experience of the user, we wanted to foster an authentic experience for participants when they tested out the tool. Therefore, we opted to do an unmoderated study, requiring users to operate the survey tool without any assistance. This is much different than most user testing with the Deaf Community since there is typically a moderator and interpreter present to clarify any questions the participant may have. Though it was a risk to not have a moderator, we felt that it was important to see how users would interact with the survey tool without help or reassurance. The information collected helped reveal the strengths and weaknesses of the survey tool overall.

7.2.1 Study Procedures

All study participants were adult members of the Deaf Community, recruited by our AEC collaborators via email to their network (Appendix C). From here, interested participants were directed to a Google Form, which took them through each step of participating in the study. They were first screened to make sure they met the participation requirements of being at least 18 years old, either Deaf or Hard of Hearing, comfortable comprehending ASL, on a computer, and on a Chrome or Firefox browser. For participants who passed the screening, informed consent was then obtained (Appendix D). This document was also summarized and provided to participants in an ASL video.

The next step of the study was to complete ASL Survey 1, which consisted of various sample questions to allow participants to try using the survey tool (Appendix E). Participants were given a link to ASL Survey 1, where they were instructed to answer the questions, submit the survey, and then return to the Google Form. Upon accessing the survey tool, participants were shown an introductory video that gave a brief overview of the procedures for the survey. They then proceeded to view and answer various multiple choice, multiple select, and scalar questions. At the end of this survey, they were shown a video explaining that they finished the survey and should submit their responses.

The step that followed was to complete ASL Survey 2, which was about their experience using the survey tool in ASL Survey 1. This is where participants were asked the ten SUS questions (Appendix F). They were first shown an introduction video that explained how this section was about evaluating their experience using the survey tool, along with the basic procedures. Users then answered the ten SUS questions, submitted this survey, and returned to the Google Form. The ASL-Gloss version of this survey can be found in Appendix G.

Once the participants completed all previous sections, they moved on to answer basic demographic questions in the Google Form (Appendix H). Lastly, participants had the option of entering their payment information so that we could compensate them for participating in the study. At this point, the study was complete. This entire process was estimated to take no more than 30 minutes.

Survey responses were collected for analysis. This included the answers to the SUS survey for each user, along with the overall demographic composition of the participant pool. All data was stored in the WPI HCI Lab's private database and Google Drive, accessible only to authorized researchers.

7.2.2 Design Process

A significant area of consideration for creating this user study was the length of the ASL surveys themselves. We wanted a low risk of users getting fatigued throughout the process. Originally, the plan was to have one ASL survey, split into two distinct sections. However, the existing framework for creating a survey did not allow for a survey of this length due to the number and size of videos being uploaded. Therefore, we split the original ASL survey into two separate, standalone surveys.

The first ASL survey consisted of sample questions about non-serious topics. These questions served to acclimate the user to the system so that they could later discuss their experience using it to take a survey. This included two multiple choice, three multiple select, and two scalar questions (in that order). We purposefully started this section with multiple choice questions because we felt this question type would be the most familiar to the user, thus making the start of the experience less jarring. We also knew we wanted to end the survey with the scalar

questions to better transition into the second survey, which also consisted of scalar questions. This meant the multiple select questions would go in the middle. This worked well because putting them adjacent to multiple choice questions would make it easier for users to tell the difference between the two question types. We decided to do one extra multiple select question to give participants more opportunities to notice its differing functionality.

The second ASL survey was questions about the application's usability with the ten questions from the SUS. As mentioned previously, there are existing translations and videos of the SUS into ASL, created to promote the inclusion of ASL signers in user studies (Berke et al., 2019). However, the videos created in that research have aspects that our AEC collaborators felt could use modifications for our application. They pointed out that the signer was sitting down and the background of the video was not ideal. The signer also used a thumbs up or down as part of the answer choice signs, which is not a part of the ASL language. Therefore, the translation team at the AEC recorded modified versions of the SUS questions to build on and improve the quality of this content. To distinguish between strongly agree and agree, the AEC opted to use YES and NO as an effect for “strongly.”

7.2.3 Participant Demographics

This user study was conducted over the span of 1.5 weeks, involving a total of 34 participants from the AEC’s network within the Deaf Community. Notably, we met our goal of having 30 participants for the study, which was important for having a sufficient sample size. Understanding the individuals who participated in the study was important in contextualizing their responses. Of the 34 participants, exactly half of the participants identified as men and half as women, and the majority, 73.5% or 25 participants, reported that they were white. All

participants identified as Deaf, meaning that we did not have any Hard of Hearing users participate. When considering education, 41.2% of participants received a Bachelor's Degree, 38.2% received a Graduate Degree, 11.8% received an Associate's Degree, and 8.8% had gone through some college but did not yet have a degree. Though we aspired to reach a more diverse user pool in terms of race/ethnicity, audiological status, and education, all users did fall into our desired user group with other demographic areas.

Another important demographic to consider was the age of participants. Figure 36 is a histogram illustrating the distribution of participants' ages. Although our study had a minimum age of 18, the youngest participant we had was 25 years old. Our oldest participant was 67, and the average age was around 42 years old. While there was a large age range, we had a notable number of participants in their 40s.

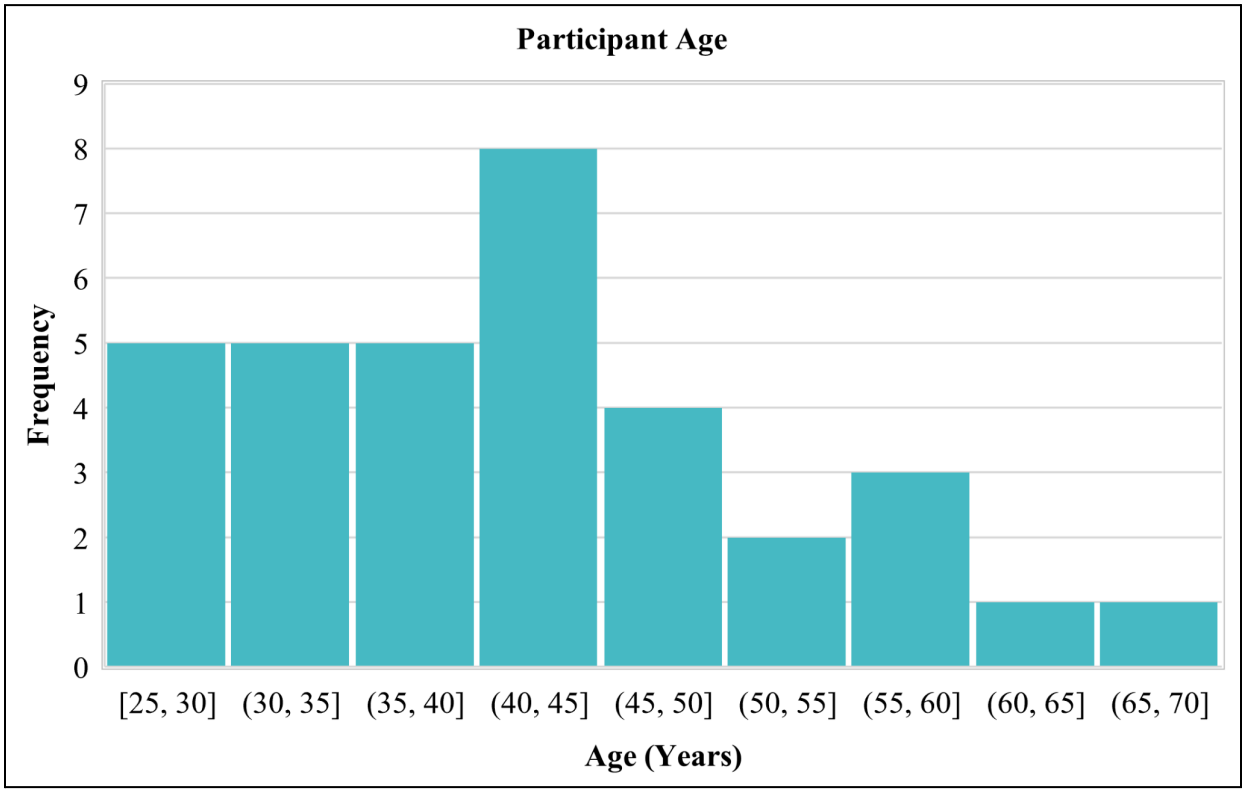

Figure 36 - Participant Age

Other demographics collected were the comfort level of participants with their ASL comprehension and self-expression (Figure 37). To participate in this study, users were required to be comfortable with comprehending ASL. Otherwise, they would be unable to properly navigate the survey tool and understand the procedures, questions, and answers. Therefore, the responses here were as expected, with most individuals being very comfortable with comprehending ASL. The results for self-expression in ASL are almost the same. Being able to express yourself in a language is different than comprehending it, but this distinction was not apparent within our participant pool.

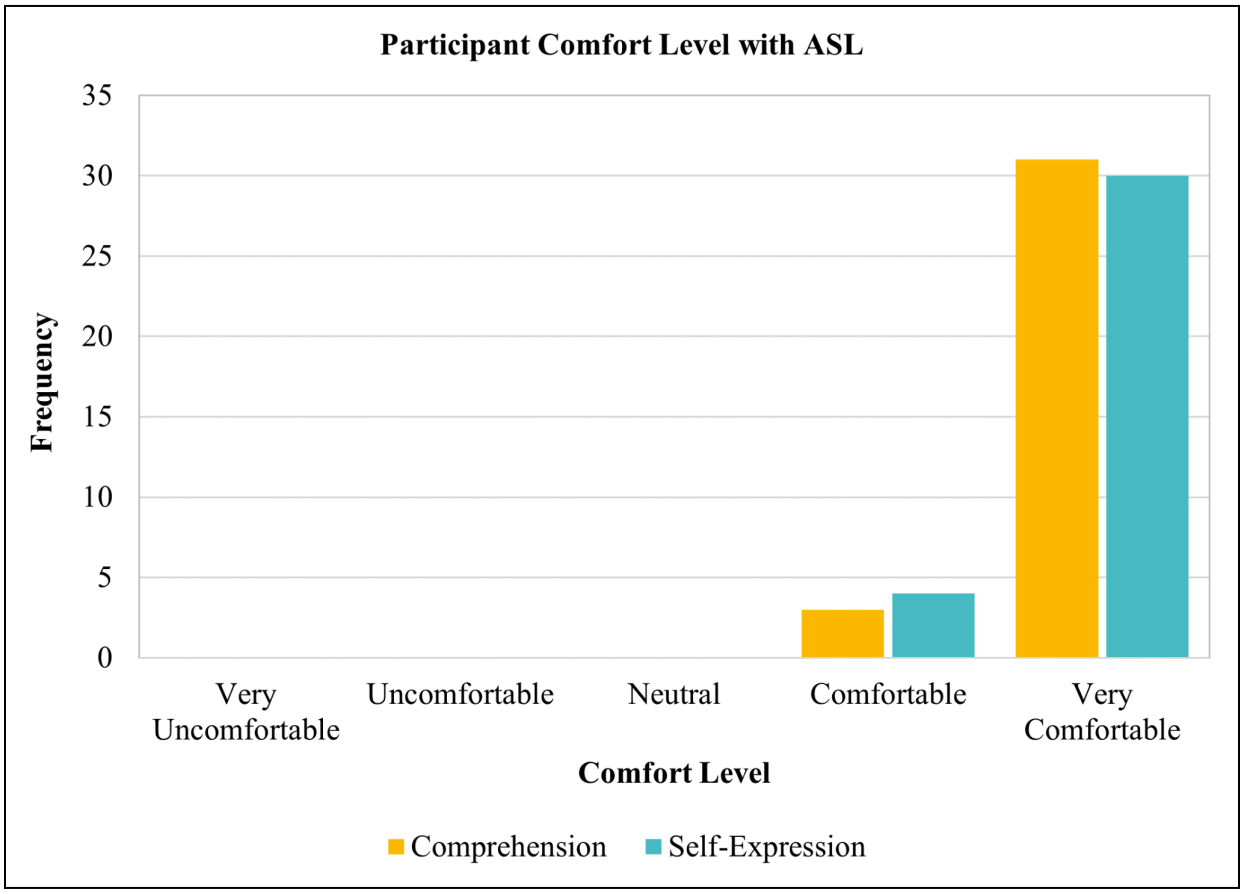

Figure 37 - Participant Comfort Level with ASL

Another area to discuss was the comfort level of participants when using English for reading and writing (Figure 38). While most participants were very comfortable with reading and writing English, there was a wider range of comfort levels in comparison to the similar ASL questions. This is important to keep in mind as our user study did include some English text, specifically within the Google Form. Running the user study completely in ASL was not possible due to the necessity of recruiting participants through email, along with signing the informed consent, answering the demographic questions, and recording payment information.

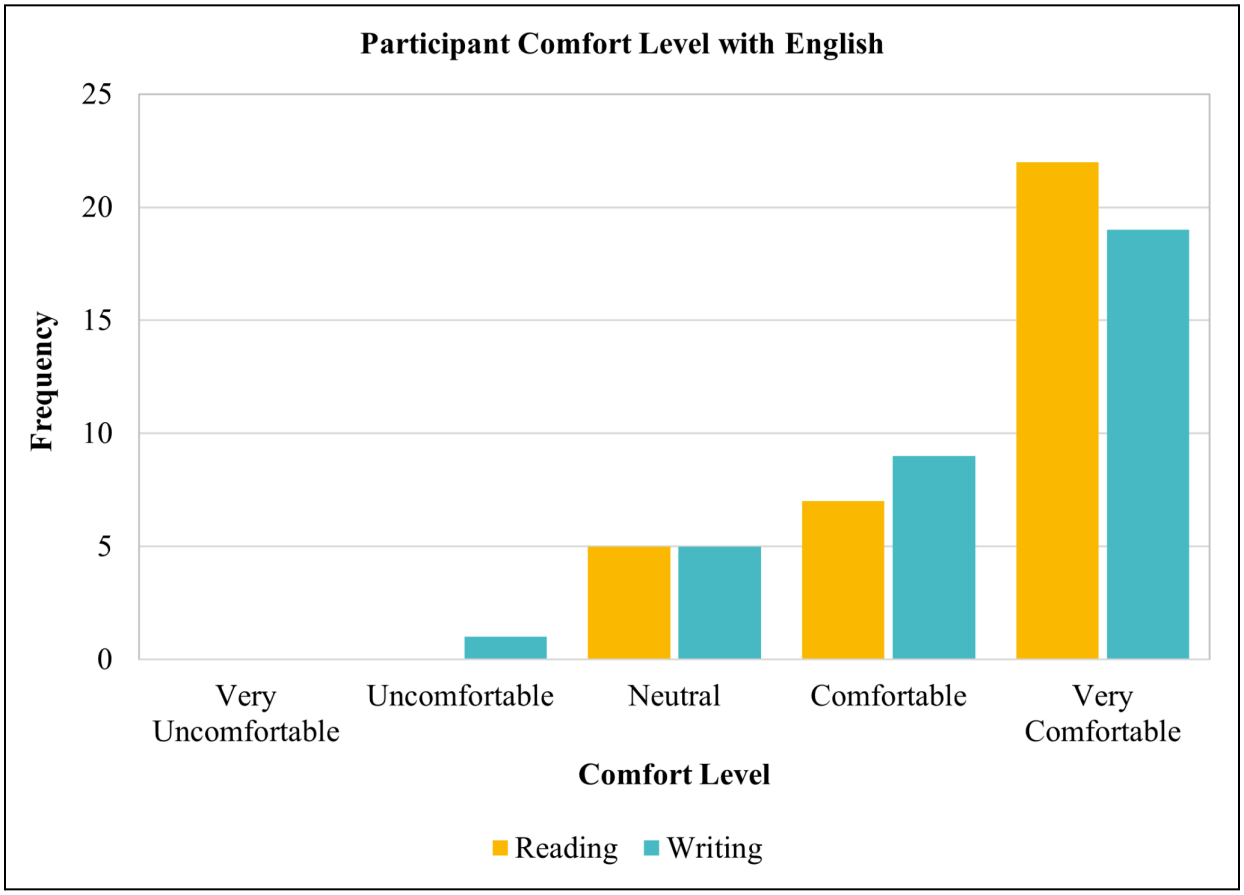

Figure 38 - Participant Comfort Level with English

7.3 Data Analysis

Using the survey tool's functionality to review user responses, we calculated the SUS score for each participant and aggregated the results over the entire group of participants. The SUS score was calculated using the following equation:

$$((x - 5) + (25 - y)) \cdot 2.5$$

where x is the sum of scores for all odd-numbered questions and y is the sum of scores for all even-numbered questions. The scores for each question were 1 through 5 corresponding to the answers of "Strongly Disagree" to "Strongly Agree." For example, a score of 3 would be equal to answering "Neutral." These calculations result in a score between 0 and 100, where a higher score corresponds to higher system usability (Brooke).

From here, we normalized the raw SUS scores to convert them to a percentile rank (Sauro, 2011). This was done by using the following equation:

$$x \,/\, (m \cdot 100)$$

where x is the score and m is the total number of scores. This allowed us to put the scores into the perspective of the specific user pool and application being tested so that we would be able to conduct fair and meaningful comparisons between different versions of the survey tool in the future as well as accounting for user variability. We also calculated and graphed the associated sigmoid function to visually depict the quartiles.

In analyzing the study results, we also looked at the demographic data to understand our participant pool and possibly identify any biases that could have been present. We aggregated the data we collected on age, ethnicity, gender, education level, comfort level with comprehending and expressing oneself in ASL, and comfort level with reading and writing English.

8 Results

8.1 Application Functionality

In creating and distributing a public survey, we were able to properly evaluate various technical aspects of the survey tool's functionality. A link to a survey was able to be sent to and opened by a user through online methods, seeing as this was how our survey was shared with study participants. This link was unique to the survey itself, using the title of the survey as part of the link. Having a readable link in English for the survey was not one of our requirements but was a good feature to include. From here, users were able to answer all three types of survey questions and submit their selected answers. The data from their submissions was accessible and able to be downloaded by the survey administrators. Therefore, the survey tool met all of our requirements identified for application functionality.

In conducting the user study, we requested that participants use a computer and be on either Chrome or Firefox as the internet browser. On mobile devices, the hover-play functionality was completely lost because of the lack of a mouse cursor, and the screen was too small to make the application usable. For the browser, we wanted to avoid users accessing the survey tool on Safari due to autoplay not working properly in other browsers.

Though we had 34 individuals participate in the study, we only had 30 submissions on the SUS survey. This meant that some participants either skipped the SUS survey or forgot to click the submit button on the survey tool itself. Even though all participants were physically able to access, answer, and submit both of the ASL surveys, the full procedure for how to do each of these steps may have been unclear. This did not have a significant impact on the results collected for this study, since this only impacted four users, but it could have much larger consequences for a survey that is distributed to a smaller pool of participants.

8.2 User Experience

After calculating the SUS scores for each user, we conducted an analysis of the reports to evaluate the application's overall usability. To visualize these scores, we created a box and whisker plot of the distribution of the scores, as seen in Figure 39. Looking at the plot, we can see that there is a longer whisker towards higher values, meaning the distribution is positively skewed. Because of this skew, we moved forward with using the median as our measure of center and the interquartile range as our measure of spread. The median score was 47.5 and the spread was 15. The highest score was 70 and the lowest was 32, so the overall range of scores was 38. There were no outliers present in the data.

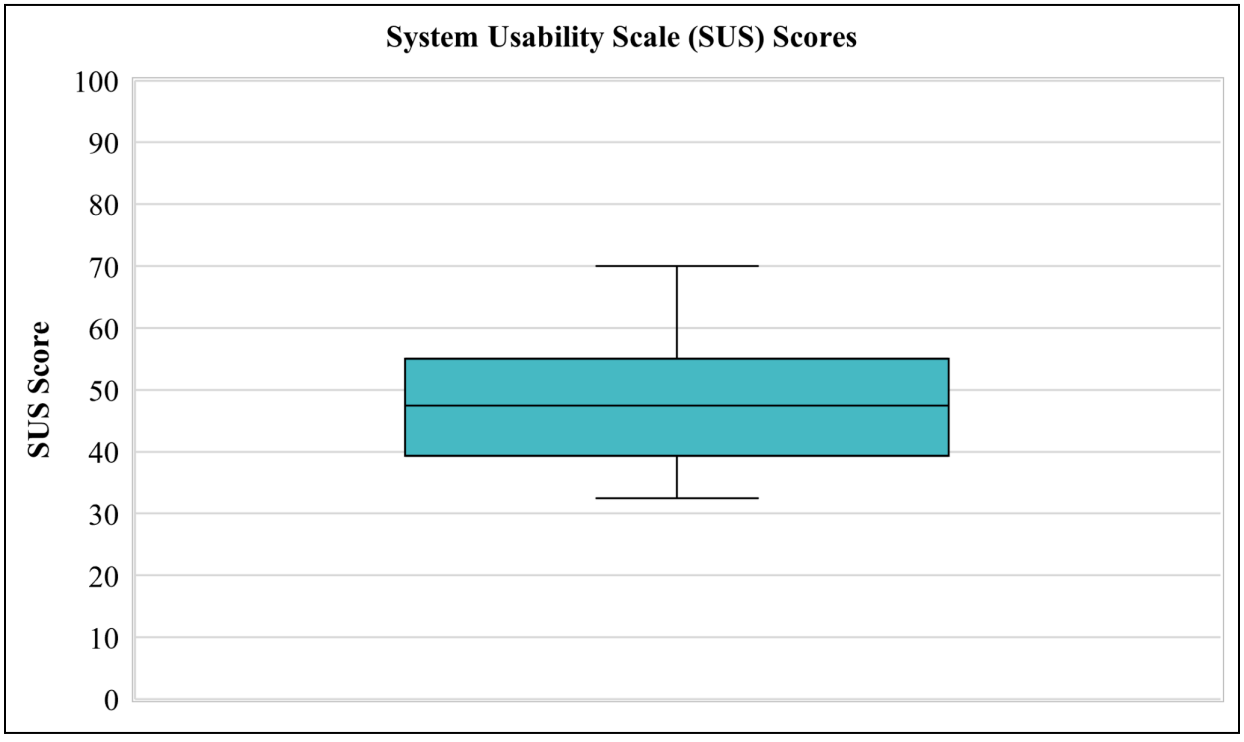

Figure 39 - System Usability Scale (SUS) Scores

When using SUS scores as a measurement of usability, there are several things to consider with the meaning of the data. The first is that these scores are not percentages. Because of this, it is vital to normalize scores so that they are put into perspective of the specific user pool and application being tested. This allows for fair and meaningful comparisons between different versions of the survey tool in the future as well as accounting for various aspects of user variability. The distribution of normalized SUS scores converted into percentile ranks can be seen in Figure 40. This figure shows the median score of 47.5 at Q2. From this interpretation, any SUS score above 47.5 would be considered above average and any SUS score below that would be considered below average.

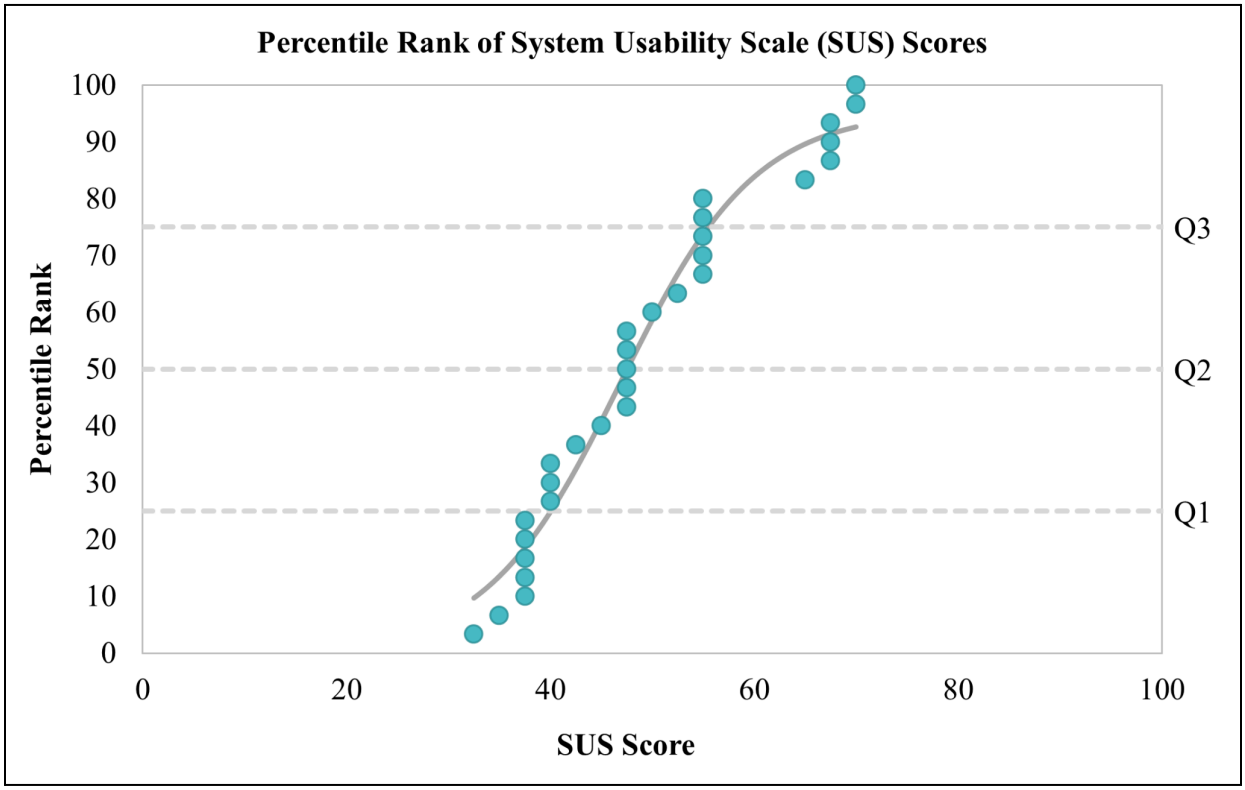

Figure 40 - Percentile Rank of System Usability Scale (SUS) Scores

Another thing to consider when using SUS as a measure of usability is how to easily define various user scores to stakeholders. To achieve this, we applied a simple grading system based on the percentile ranking (Figure 41). We graded scores into 4 categories based on the quartiles: excellent, good, okay, and poor. This allowed us to easily visualize and communicate our findings with our AEC sponsors. The collected information will also be important to use as a baseline for future iterations of the tool, enabling future teams to evaluate whether their newly implemented features have positively or negatively impacted the usability of the tool.

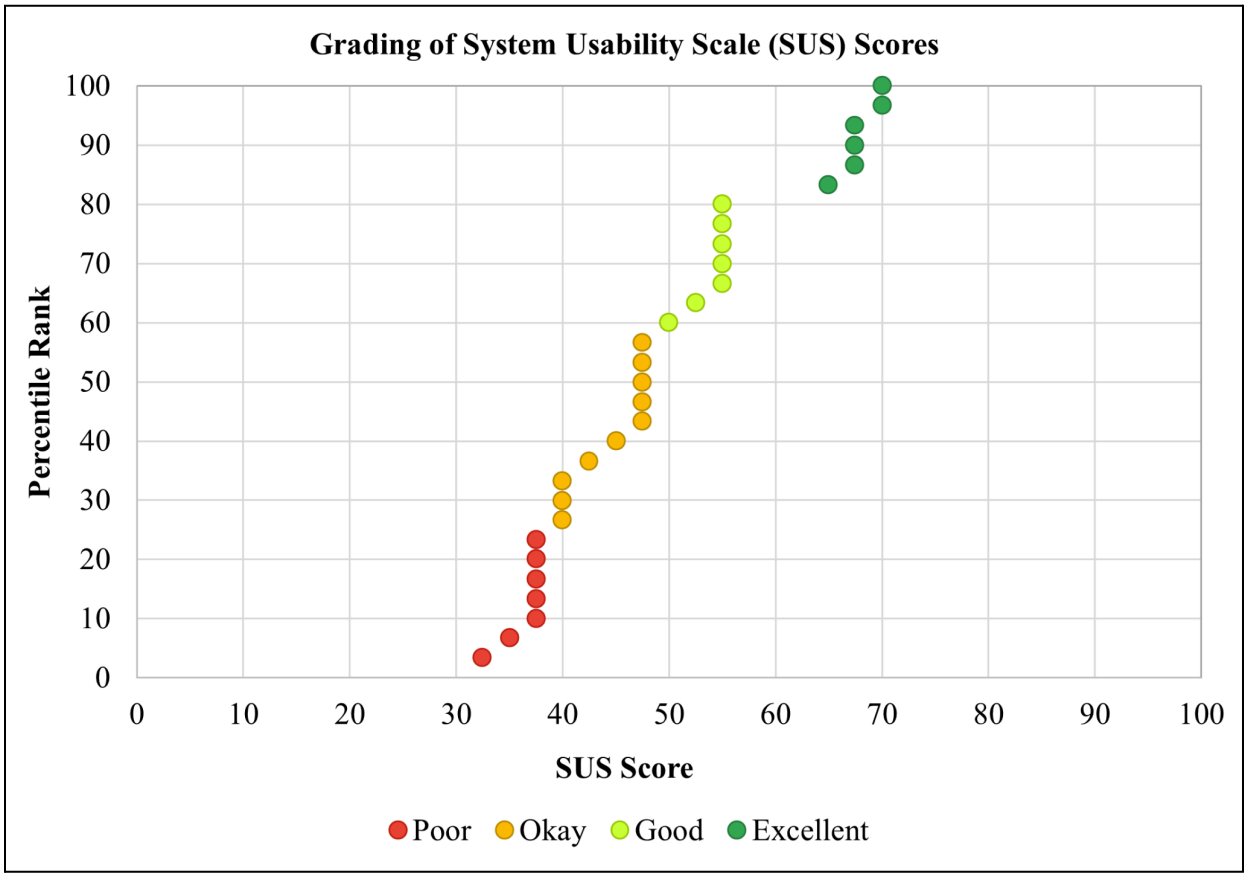

Figure 41 - Grading of System Usability Scale (SUS) Scores

9 Discussion

After completing our initial analysis and discussing these results with our AEC collaborators, all parties agreed that there were possible aspects of the user study design that could have impacted the SUS data. We analyzed various components of the study and the data collected to identify the intricacies of the study process. Additionally, due to the fact that AEC's researchers are members of the Deaf Community, which is small and well-connected, several participants chose to discuss freely with our AEC collaborators about their opinions and experiences with the study. This information was also vital in guiding us through addressing this part of the problem statement.

9.1 Design of the SUS Survey

The first topic of interest is the nature of the SUS questions themselves. While the answer scale never physically changed, the meaning of these answers flipped every other question, as is the nature of SUS questions. For example, "Strongly Agree" would be a positive response in Question 1, but a negative response in Question 2, this pattern continuing for all ten questions. It was possible for a participant to have naturally assumed that the scale went from negative to positive (right to left) for every question after seeing this format in Question 1, which would have resulted in much lower SUS scores. This means that participants who scored all "Agree" and "Strongly Agree" or all "Disagree" and "Strongly Disagree" are both notable. To locate these users, we looked at the sum of their total scores, using the numbers 1 through 5 to represent the answer scale. Specifically, we looked at users whose total sum of answers was greater than 40 (all 4's) and less than 17 (a mixture of 1's and 2's) and found ten users who fit this criteria.

To see how this impacted the overall SUS scores, we removed the scores of the ten users and regenerated the histogram. Figure 42 shows the adjusted box and whisker plot, which does have some distinct changes from Figure 39. Noticeably, the median increased by about 7.5 points, the quartiles shifted upwards, and the interquartile range increased by five points.

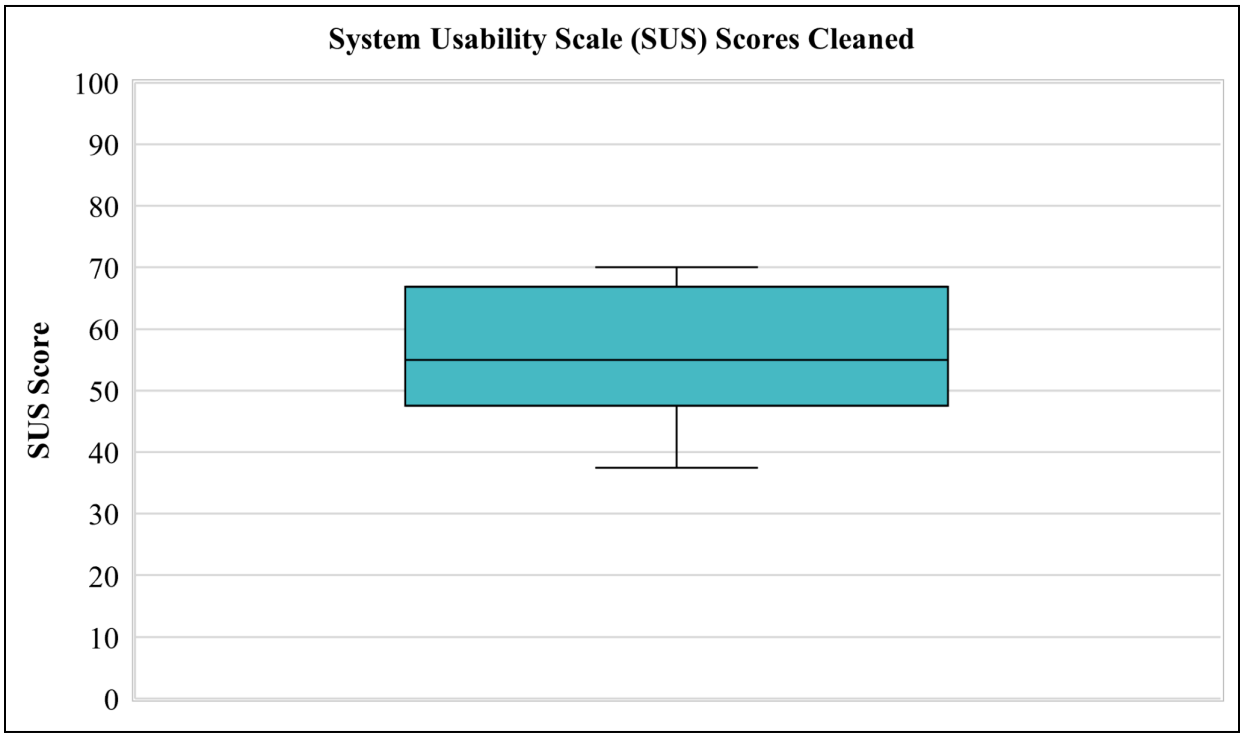

Figure 42 - System Usability Scale (SUS) Scores Cleaned of Users Who Consistently Disagreed or Agreed with Each Statement

While we do not know for certain the reason behind the behavior of participants who always disagreed or always agreed with every statement, this shift in the results should not go unnoticed. Without a moderator present, participants were unable to easily ask for clarification or be redirected if they were misinterpreting the procedures. Traditionally, the ASL SUS has been administered with a researcher on-site to help with any questions. The fact that we were also

distributing it through a piece of novel technology only compounded the potential confusion. Looking specifically at the study where the SUS was originally translated and tested in ASL, it was only administered physically in person and to university-aged students (Berke et al., 2019). Our participants were all older than those of the other study and completely online, presenting another interesting difference in our study design.

9.2 Introduction Video Clarity

Another potential area of complexity was the introduction videos shown to participants in each ASL survey. Specifically looking at the introduction for the SUS questions, there was a lack of clarity in conveying the purpose and procedures of the SUS survey itself. The sign in ASL for "question" and "survey" are very similar, so the AEC translation team tried to avoid using these words too frequently in the introduction video in hopes of limiting confusion. While this was important for signing clarity, it prevented participants from receiving needed clarification of what they were evaluating with the SUS questions.

This lack of context could have produced a wide variety of interpretations of the SUS. Some users may have thought that they were to answer based on how much they liked the SUS questions or the content of the sample questions, rather than the experience of taking the survey itself. Another possible option here was that users were evaluating the overall process of participating in the user study, which could have easily produced negative results due to the complicated nature of going back and forth between the Google Form and the ASL Survey Tool. Our AEC collaborators have identified that in retrospect, in trying to make the instructions more clear for users, they may have oversimplified them and the original meaning and purpose of the study we had hoped to convey was lost for some users.

9.3 Positive Anecdotes

Through casual discussions with study participants, our AEC collaborators were given a great amount of positive feedback regarding the survey tool itself. People were overall quite happy with the functionality of the tool. They liked the various colors included in the application, such as the indicators of blue for playing and green for selection. Participants complimented all of the different elements of the survey on screen and felt that the interface design overall made sense conceptually. They liked how their answers were captured and the feedback that indicated this, along with the shapes of the videos. Some users felt that the survey tool was not something they personally needed, but saw it as a valuable resource for other members of the Deaf Community. These sentiments are of a much different tone than the results of the SUS survey, indicating a severe disconnect between SUS scores and people's overall feelings about the survey tool. Because the SUS was only about usability and not interface design, this positive feedback unfortunately was lost in our documented study results. We are incredibly grateful for the participants who talked about their experiences with the AEC, as this helped in contextualizing the results and guiding our analysis of the study itself.

10 Future Work

Throughout our project, we generated various ideas to enhance and optimize the ASL Survey Tool. Though the tool is fully functional, our experience of conducting an unmoderated user study with it has revealed various intricacies, highlighting the need for additional features and further considerations. This is crucial not only for refining the tool but also for advancing our overarching goal to enhance the accessibility of participating in research for ASL signers. Based on our findings, the ASL Survey Tool is well prepared for significant enhancements across three pivotal areas within the near future: (1) quantitative metric collection, (2) administrative features, and (3) survey functionality.

10.1 Quantitative Metric Collection

As we analyzed other survey tools, we realized that certain quantitative metric data would be useful for SL1 technology researchers. Some examples of potential metric data to collect include timestamps for when pages load, along with when a user plays a question video, plays an answer video, selects an answer, switches to a different question, and submits the survey. This data would be stored in a log alongside the user's responses to the survey. Since the tool currently has the capability for this data collection locally, being able to store the data from external users would highly benefit future teams in analyzing the performance of future updates of the survey tool. We also suggest adding an option for administrators to be able to turn data logging on and off, as it is not a necessary feature but will undoubtedly be beneficial for SL1 researchers in particular.

10.2 Administrative Features

Since the tool is currently functional with one main administrator account, introducing multiple administrator accounts through a structured login system would allow for greater use of the tool by a wider audience. Along with this comes the necessity of a more structured file system within the S3 bucket that is partitioned for each administrative user. This is especially useful if the survey tool is being used by more than one group of researchers, so that survey media and results can be kept private and separated. Looking forward, this would be important for distributing the tool to clients so that media storage costs can be managed appropriately.

There are also several back-end features related to media management that would pair very well with this expansion of the administrator role. Many surveys use the same answer choices for different questions, such as the SUS survey, which had ten questions all with the same answer choices. One way to address this redundancy in the media storage is by allowing a video file to be reused multiple times within a single survey. This could be implemented with a browsing system or a feature to identify and delete duplicate videos within the cloud storage. Another improvement related to media is being able to upload an image or select a specific frame as a video thumbnail to be displayed in the survey. Currently, to create a thumbnail, the survey creator must pre-edit the video to include the poster image at the beginning of the video. Removing this extra step in editing takes a significant burden off of the survey creator.

With the implementation of an administrator login system, media storage partitions, and improved media management, the user experience of the survey creator would be improved significantly. Other features such as the ability to make a question required, survey creation feedback and error messaging, and improved user interface design would also greatly benefit the administrator side and are viable next steps in development given the tool's current state.

10.3 Survey Functionality

Shifting to the survey taker interface, there are several improvements to be made as a result of our user study and discussion with our AEC collaborators. Firstly, the tool currently has a responsive user interface for Google Chrome and Firefox browsers, but implementing this functionality for other browsers could help create a universal experience for all users.

Another feature that would be helpful to implement would be a functional help button. This help button would include a description of each question type, how to answer questions, how to navigate through the survey, and an explanation of how the hover-play functionality works. By giving users an explanation of these unique elements, which are distinct from text-based survey tools, the learning curve would be reduced and it would be easier to get into the overall rhythm of using this novel tool.

Finally, adding the ability for free-response questions could be useful for future surveys. The general idea would be for users to record and upload their answers as a video in ASL. This would give the survey tool a new range of abilities to collect a wider variety of data from participants. For example, a user would have the ability to identify themself by signing their name or can have the option to freely express their opinions in their native language.

11 Conclusion

Looking back at our problem statement, we achieved our overall goals for the project. We (1) created and deployed a fully functional ASL-centric survey tool, which was then (2) tested and evaluated in an unmoderated setting with a user study sent to the Deaf Community.

We collected quantitative data on the usability of the tool from survey takers, creating a documented and detailed baseline for future iterations of the application. Since the ASL Survey Tool is a novel piece of technology where participants likely had no prior experience using a similar system, we are incredibly satisfied with the usability scores and are excited to see how the tool will improve in the future.

The user study process itself had its own complexities, specifically related to the nature of the SUS survey format and the content of introduction videos. This identification serves as an important note for future researchers so that they can be mindful of these specific areas when designing other unmoderated surveys in ASL.

Through continuous work on the survey tool and communication with our Deaf collaborators at the AEC, we identified several areas of improvement for the application. Whether it be new features for survey creators or survey takers, these ideas should fuel future research and development of the tool.

By providing a culturally aware interface for users to express themselves in ASL, the survey tool not only addresses linguistic inequities but also raises the standard of engagement in situations that require high-quality information processing. For example, in settings like healthcare and academia where comprehension is vital to success, the tool is capable of becoming a critical resource to facilitate effective and in-depth communication.

The ASL Survey Tool in its current state emerges not only as an innovative contribution to technology for the Deaf but also as a precursor to defining standardized design principles for future SL1 technology. We hope that there will soon be a day when digital accessibility becomes a truly universal standard. With the transformative power of technology, the ASL Survey Tool has the potential to provoke a broader movement towards a digitally equitable world.

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Bibliography

Abdulghafoor, M. S., Ahmad, A., & Huang, J.-Y. (2015). Survey on the use of applications for Deaf and Hard Hearing literacy. *2015 International Conference on Computer, Communications, and Control Technology (I4CT)*, 242–247. https://doi.org/10.1109/I4CT.2015.7219574

Berke, L., Huenerfauth, M., & Patel, K. (2019). Design and Psychometric Evaluation of American Sign Language Translations of Usability Questionnaires. *ACM Transactions on Accessible Computing*, *12*(2), 1–43. https://doi.org/10.1145/3314205

Boll, R., Mahajan, S., Burke, T., Alkhudaidi, K., Henriques, B., Cordova, I., Walker, Z., Solovey, E., & Reis, J. (2023). User Perceptions and Preferences for Online Surveys in American Sign Language: An Exploratory Study. *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*, 1–17. https://doi.org/10.1145/3597638.3608444

Boll, R., Mahajan, S., Reis, J., & Solovey, E. T. (2020). Creating questionnaires that align with ASL linguistic principles and cultural practices within the Deaf community. *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, 1–4. https://doi.org/10.1145/3373625.3418071

Bosch-Baliarda, M., Soler Vilageliu, O., & Orero, P. (2019). Toward a Sign Language-Friendly Questionnaire Design. *The Journal of Deaf Studies and Deaf Education*, *24*(4), 333–345. https://doi.org/10.1093/deafed/enz021

Brooke, J. (1995, November). *SUS: A quick and dirty usability scale*. https://www.researchgate.net/publication/228593520_SUS_A_quick_and_dirty_usability_scale

Built-in React Hooks. (n.d.). React. Retrieved October 9, 2023, from https://react.dev/reference/react

Cordova, I., & Henriques, B. (2022). *Towards Inclusive Learning and Research with Sign Language Surveys*. https://digital.wpi.edu/show/kd17cx042

CSS: Cascading Style Sheets. (2023, July 22). MDN Web Docs. https://developer.mozilla.org/en-US/docs/Web/CSS

Gala, A. S. (2023, March 9). *Deaf culture: what is it, history, aspects, examples & facts*. Hand Talk. https://www.handtalk.me/en/blog/deaf-culture/

Getting started with React. (2023, September 24). MDN Web Docs. https://developer.mozilla.org/en-US/docs/Learn/Tools_and_testing/Client-side_JavaScript_frameworks/React_getting_started

Henney, A. J., & Chininthorn, P. (2021). A mobile survey for collecting data from Deaf people who use sign language for communication. *2021 Conference on Information Communications Technology and Society (ICTAS)*, 79–84. https://doi.org/10.1109/ICTAS50802.2021.9394973

HTML: HyperText Markup Language. (2023, July 17). MDN Web Docs. https://developer.mozilla.org/en-US/docs/Web/HTML

Lapiak, J. (n.d.-a). *Adverbs in American Sign Language*. HandSpeak. Retrieved November 6, 2023, from https://www.handspeak.com/learn/33/

Lapiak, J. (n.d.-b). *Signs for SOON*. HandSpeak. Retrieved November 6, 2023, from https://www.handspeak.com/word/2023/

Mahajan, S., Walker, Z., Boll, R., Santacreu, M., Salvino, A., Westfort, M., Reis, J., & Solovey, E. (2022). Towards Sign Language-Centric Design of ASL Survey Tools. *Proceedings of*

the 2022 CHI Conference on Human Factors in Computing Systems, 1–16. https://doi.org/10.1145/3491102.3502047

Reis, J., Solovey, E. T., Henner, J., Johnson, K., & Hoffmeister, R. (2015). ASL CLeaR: STEM Education Tools for Deaf Students. *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility*, 441–442. https://doi.org/10.1145/2700648.2811343

Santacreu, M. (2021). *Developing and Studying Novel Sign Language Technology*. https://digital.wpi.edu/show/mp48sg62c

Sauro, J. (2011, February 3). *Measuring Usability with the System Usability Scale (SUS) – MeasuringU*. https://measuringu.com/sus/

System Usability Scale (SUS). (2013, September 6). Usability.Gov. https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html

UR2PhD: Undergraduate Research to PhD Mentoring. (n.d.). CRA: Computing Research Association. https://cra.org/ur2phd/

Using color. (n.d.). U.S. Web Design System (USWDS). Retrieved October 13, 2023, from https://designsystem.digital.gov/design-tokens/color/overview/

Version Control Best Practices. (n.d.). Git Tower. Retrieved October 12, 2023, from https://www.git-tower.com/learn/git/ebook/en/command-line/appendix/best-practices

Vicars, W. (n.d.). *American Sign Language: "birthday."* Lifeprint. Retrieved November 6, 2023, from https://www.lifeprint.com/asl101/pages-signs/b/birthday.htm

Warren, R. (n.d.). *Kanban Dev Board*. Trello. Retrieved October 12, 2023, from https://trello.com/templates/engineering/kanban-dev-board-lvRpONOJ

Web Content Accessibility Guidelines (WCAG) 2.2. (2023, October 5). https://www.w3.org/TR/WCAG22/

What is JavaScript? (2023, October 3). MDN Web Docs. https://developer.mozilla.org/en-US/docs/Learn/JavaScript/First_steps/What_is_JavaScript

World Federation of the Deaf. (2016, August). Human Rights of the Deaf. *WFD*. https://wfdeaf.org/our-work/human-rights-of-the-deaf/

Appendix A: User Interface Requirements

Questions	Q. Type	New?	Priority	Time
Type				
Multiple Choice (MC)	MC	No	High	Medium
Multiple Select (MS)	MS	No	Medium	Medium
Scalar (S)	S	No	Low	High
Sizing and Spacing	**Q. Type**	**New?**	**Priority**	**Time**
Question videos				
Default: 640 x 480 px	MC/MS/S	No	High	Low
Rounded corners: 24 px	MC/MS/S	No	High	Low
Answer choices				
Default: 200 x 200 px	MC/MS/S	No	High	Low
Selection border width: 12 px	MC/MS	No	High	Low
Hover zone: 24 px	MC/MS	Yes	High	Medium
Circle video shape	MC	No	High	Low
Rounded corners: 24 px	MS	No	High	Low
Scalar levels				
Button size default: 24 px	S	No	High	Low
Spacing				
Between question and answer: 40 px	MC/MS	No	High	Low
Minimum between hover zones: 8 px	MC/MS	Yes	High	Low
Responsivity				
All elements respond to page size	MC/MS/S	Yes	High	Medium

System Colors	Q. Type	New?	Priority	Time
Backgrounds				
Body: Gray-cool-1 #FBFCFD	MC/MS/S	Yes	High	Low
Survey: Gray-cool-5 #EDEFF0	MC/MS/S	Yes	High	Low
Button outlines				
Hover: Blue #2491FF	MC/MS/S	Yes	High	Low
Selection: Green #00A91C	MC/MS/S	Yes	High	Low
Color Indicators	**Q. Type**	**New?**	**Priority**	**Time**
Question videos				
Inactive: black border	MC/MS/S	Yes	High	Low
Video playing: blue border	MC/MS/S	Yes	High	Medium
Answer choices				
Inactive: black radio button	MC	Yes	High	Medium
Inactive: black check box	MS	Yes	High	Medium
Video playing: blue outline	MC/MS	Yes	High	Medium
Selected: green outline	MC/MS	No	High	Low
Scalar levels				
Inactive: black radio button	S	Yes	High	Low
Video playing: blue radio button	S	Yes	High	Medium
Selected: green radio button	S	Yes	High	Low
(A/B) Video playing: blue solid circle	S	Yes	Low	Medium
(A/B) Selected: green solid circle	S	Yes	Low	Low
Progress bar				
Use colors to indicate question status	MC/MS/S	Yes	Medium	Medium

Application Layout	Q. Type	New?	Priority	Time
Questions				
Answer choices below the question	MC/MS	No	High	Low
Answer scale beside the question	S	No	High	Low
Progress bar				
Located at bottom, horizontal	N/A	No	High	Medium
(A/B) Located at top, horizontal	N/A	Yes	Low	Medium
(A/B) Located at left side, vertical	N/A	Yes	Low	Medium
(A/B) Located at right side, vertical	N/A	Yes	Low	Medium
Menu				
(Eye Track) Drop-down, column	N/A	Yes	Low	High
(Eye Track) Drop-down, horizontal	N/A	Yes	Low	High
(Eye Track) Drop-down, circular	N/A	Yes	Low	High
Hover-Play Functionality	**Q. Type**	**New?**	**Priority**	**Time**
Hover zone				
Hover near answer choice plays video	MC/MS	Yes	High	Medium
Scalar levels				
Video for each scale level	S	No	High	Medium
Hover on level plays answer video	S	Yes	High	Medium
Appearance				
Question video will autoplay	MC/MS/S	No	High	Low
Active video's size is increased	MC/MS	Yes	High	Low
Inactive videos are grayed out	MC/MS	Yes	Medium	Low

Appendix B: Functionality Requirements

Minimum Viable Product	New?	Priority	Time
Media storage			
Create S3 bucket with HCI Lab root user	Yes	High	Medium
Create administrator IAM role	Yes	High	Medium
Connect S3 bucket to survey tool	No	High	Medium
Accessibility			
Host application on WPI server	No	High	High
Generate public survey URLs	No	High	High
Functionality			
User can view all survey media	No	High	Medium
User can answer multiple choice questions	No	High	Medium
User can answer multiple select questions	No	High	Medium
User can answer scalar questions	No	High	Medium
User can navigate between questions	No	High	Medium
User can submit a completed survey	No	High	Medium
Submitted survey responses are saved	No	High	Medium
Submitted survey responses are exportable	No	High	Medium

Metric Collection	New?	Priority	Time
Data recording			
Timestamp of when page loads	No	Medium	Medium
Timestamp of when user plays question video	No	Low	Medium
Timestamp of when user plays answer video	No	Low	Medium
Timestamp of when user selects answer	No	Low	Medium
Timestamp of when user changes questions	No	Low	Medium
Timestamp of when user submits survey	No	Medium	Medium
Metrics saved when survey is submitted	No	Medium	High
Other Back-End Features	**New?**	**Priority**	**Time**
Admin			
Admin can delete an existing survey	Yes	Medium	High
Admin can delete a question from survey	Yes	Medium	High
Admin can delete a video from S3, either through deleting a question or a survey	Yes	Medium	High
Turn data logging on and off	Yes	Medium	High
Multiple admin accounts with private, partitioned media storage in S3	Yes	Low	High
Survey creation			
Upload an image for a video thumbnail	Yes	Medium	Medium
Select existing video in S3 to use in survey	Yes	Low	High
Support for free response questions, with the user's response being to upload a video	Yes	Low	High
Media management			
Check for duplicate videos in S3	Yes	Low	High
Browse videos in S3 for reuse and delete	Yes	Low	High

Appendix C: Email Request for Participation

Hello!

Our team at the ASL Education Center is looking for study participants to evaluate an online ASL Survey Tool.

The study will take about 30 minutes to finish. It is all done online. You will receive $10 when you have completed the study.

We would like to know about your experience while using this ASL Survey Tool. Your feedback will allow the team to evaluate the project and create plans for future research and development.

This ASL Survey Tool allows ASL-signing individuals to take a survey entirely in ASL. It was created by a team at ASL Education Center, working with students from Worcester Polytechnic Institute (WPI).

The study will close on February 9, 2024, so please join the study soon if you are interested!

Click the link below and follow all instructions.
https://forms.gle/wL7Txxy3AxV5Zp2j6

*This study is approved by the WPI Institutional Review Board (IRB-24-0367). Please feel free to email the research team if you have any questions: gr-aslmqp23@wpi.edu.

Appendix D: Informed Consent Agreement

Principal Investigator: Dr. Erin T. Solovey and Jeanne Reis

Contact Information: esolovey@wpi.edu, gr-aslmqp23@wpi.edu, jeanne@asledcenter.org

Title of Study: Evaluating a Survey Tool Based in American Sign Language

Introduction: You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks, or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of study: We are conducting this study to evaluate the overall user experience of an ASL Survey Tool for Deaf and Hard of Hearing users. The results will inform the design of this survey tool and other similar platforms to better serve Deaf and Hard of Hearing users.

Procedures: This study will take about 30 minutes. It will proceed as follows:

1. If you agree to these terms, you will click YES and acknowledge the informed consent agreement by writing your name. Then, you will click NEXT at the bottom-left of the Google Form.
2. Keep this Google Form open in your browser during the whole study. You will come back to it several times.
3. You will take ASL Survey 1, answering sample questions in the survey tool.

4. After submitting your answers in ASL Survey 1, come back to this Google Form page and click NEXT.
5. You will take ASL Survey 2, answering questions about your experience using the survey tool to take ASL Survey 1.
6. After submitting your answers to ASL Survey 2, come back to this Google Form page and click NEXT.
7. You will answer demographic questions and then click NEXT.
8. You will say YES or NO to sharing your payment information so we can pay you $10 for participating, and then click NEXT.
9. If you answered YES, enter your payment information and then click SUBMIT.
10. How participant data will be used: All data collected will be aggregated for analysis and report purposes. There will be no direct quotes in any report created from this study.

Risks to study participants: There are no risks or privacy concerns to participants. Survey data is collected anonymously, so the research team will not be able to identify participants.

Benefits to research participants and others: There are both immediate and potential future benefits for participants. The immediate benefit is receiving $10. The potential future benefits include helping contribute to the development of this ASL-based system and the development of other ASL-centric interfaces in the future.

Record keeping and confidentiality: No individual data will be reported since individual answers will be combined with those of all respondents for analysis and reporting. No contact

information will be collected since the survey does not have free-response and no questions ask for information like names or addresses. Data will be stored on a secure Google Cloud Drive that only authorized members of the research team will have access to.

Compensation or treatment in the event of injury: You do not give up any of your legal rights by agreeing to participate in this study. There is no risk of physical injury.

Payment: Study participants will be sent $10 at the end of the study.

For more information about this research or the rights of research participants, contact: Professor Erin Solovey, Tel. 508-831-6936, Email: esolovey@wpi.edu, IRB Manager, Ruth McKeogh, Tel. 508 831-6699, Email: irb@wpi.edu, and the Human Protection Administrator, Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Refusal to participate in this study will not penalize you in any way or cause any loss of benefits. You may decide to stop participating at any time without penalty or loss of benefits. No questions in the survey are required. If you would like to not answer the question, move on to the next question without selecting an answer choice. By signing below and taking the survey, you acknowledge that you have been informed about and consent to be a participant in the study described above. Please reach out if you have any questions regarding participation, and make sure that your questions are answered to your satisfaction before agreeing to participate.

Appendix E: ASL Survey 1 (English)

Introduction

Welcome to the survey to show you the ASL Survey Tool system. This survey includes three types of questions. The first type is a multiple choice question with four answer options, where you select one answer. The second type is a multiple select question with four possible answer options, where you can select all that apply. The third type is a scalar question, where you use the scale to choose your answer. Please ignore the sign content of the questions and instead focus on the experience of using the survey tool. When you have completed the survey, submit your responses by clicking the upload button at the end of the navigation bar. When you are ready to start, press the arrow to the right to continue.

Survey Questions

1. Which of these colors do you like best? (Multiple Choice)
    a. Red b. Blue c. Green d. Purple

2. Which of these fruits do you like best? (Multiple Choice)
    a. Apple b. Banana c. Pineapple d. Orange

3. Which of these types of games do you like to play? (Multiple Select)
    a. Board Games b. Card Games c. Video Games d. VR Games

4. What methods of transportation do you use? (Multiple Select)
    a. Car b. Subway c. Bus d. Train

5. Which of these activities do you do in the winter? (Multiple Select)

    a. Ice Skating b. Skiing / Snowboarding c. Snowmobiling d. None of These

6. What is your cooking skill level? (Scalar)

    a. Beginner b. Learning c. Average, Can Cook d. Specialist e. Expert

7. How much do you agree/disagree with this statement? “I enjoy playing sports.” (Scalar)

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

Conclusion

Thank you for completing this section. You have reached the end of the survey and can submit your responses using the upload button at the end of the navigation bar.

Appendix F: ASL Survey 2 (English)

Introduction

Welcome to the survey about your experience using the ASL Survey Tool. Please answer each question to the best of your ability. You should reflect and analyze your experience using the ASL Survey Tool in the previous survey. For each of the following statements, select how much you disagree or agree with the statement about the survey tool application. When you have completed this survey, submit your responses by clicking the upload button at the end of the navigation bar. When you are ready to start, click the arrow to the right to continue.

Survey Questions

1. I think that I would like to use this system frequently.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

2. I found the system unnecessarily complex.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

3. I thought the system was easy to use.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

4. I think that I would need the support of a technical person to be able to use this system.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

5. I found the various functions in this system were well integrated.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

6. I thought there was too much inconsistency in this system.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

7. I would imagine that most people would learn to use this system very quickly.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

8. I found the system very cumbersome to use.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

9. I felt very confident using the system.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

10. I needed to learn a lot of things before I could get going with this system.

    a. Strongly Disagree b. Disagree c. Neutral d. Agree e. Strongly Agree

Conclusion

Thank you for completing this section. You have reached the end of the survey and can submit your responses using the upload button at the end of the navigation bar.

Appendix G: ASL Survey 2 (ASL-Gloss)

Introduction

WELCOME THIS EXPERIENCE SURVEY

QUESTION GOING-FORWARD

YOU GO-AHEAD ANSWER BEST YOU CAN

(pause)

RECENT YOUR EXPERIENCE

JOURNEY, YOU ANALYZE

NEXT WILL INQUIRE++ RELATE YOUR

OVERALL EXPERIENCE

YOU GO-AHEAD ANSWER

HOW, LIKERT SCALE RANGE

YES-AGREE

x-RANGE

NO-DISAGREE

x-RANGE CLICK

(pause)

TAKE-ON SURVEY FINISH,

LOOK BOX END-POINT CLICK-UPLOAD

UPLOAD

(pause)

YOU READY? GO-AHEAD!

Survey Questions

1. ME LOOK-AT (screen)

   (NOD) DON'T-MIND

   USE THIS FREQUENT

2. ME LOOK-AT (screen)

   WOW COMPLEX

3. ME LOOK-AT (screen)

   WOW EASY UNDERSTAND

4. ME LOOK-AT (screen)

   ME DON'T-MIND

   UNDERSTAND, NEED HELP

5. ME LOOK-AT (screen)

   DIFF, DIFF POINT++

   (NOD) (emphasis) POINT (screen)

   ASL-CENTRIC INTEGRATED

6. ME LOOK-AT (screen)

   DIFF, DIFF POINT++

   (NOD) (emphasis) POINT (screen)

   ASL-CENTRIC INTEGRATED-(NOT)

7. ME LOOK-AT (screen)

   ME IMAGE MOST PEOPLE-AREA

   EASY ACQUIRE

8. ME LOOK-AT (screen)

   WHEEEW, ME AWKWARD ACQUIRE

9. ME LOOK-AT (screen)

   (NOD) EASY ACQUIRE, CONFIDENT

10. ME LOOK-AT (screen)

    FIGURE-OUT PROGRESS

    OH, (+) ACQUIRE

Conclusion

RECENT TAKE SURVEY FINISH, THANK YOU!

LOOK-BELOW ROW (LAST)-POINT CLICK

YOUR RESPONSE UPLOAD

Appendix H: Demographic Questions

1. What is your age?
    a. _____
2. What is your identity?
    a. Deaf
    b. Hard of Hearing
3. What is your race/ethnicity? Check all that apply.
    a. African/African American/Black
    b. American Indian/Native American
    c. Asian/Asian American
    d. Caucasian/European American/White
    e. Hispanic/Latino/Latina/Latinx/Latine
    f. Middle Eastern or North African (e.g., Lebanese, Egyptian, Algerian, etc.)
    g. Pacific Islander/Pacific Islander American
    h. Prefer not to answer
    i. Other: _____
4. What is your gender? Select all that apply.
    a. Man
    b. Woman
    c. Non-Binary
    d. Prefer not to answer
    e. Other: _____

5. What is the highest level of school you have completed?
    a. Some high school
    b. High school diploma or equivalent (e.g., GED)
    c. Some college but no degree
    d. Associate's degree
    e. Bachelor's degree
    f. Graduate degree
6. How much do you agree/disagree with this statement?

    I am very comfortable with comprehending ASL.
    a. Strongly disagree
    b. Disagree
    c. Neutral
    d. Agree
    e. Strongly agree
7. How much do you agree/disagree with this statement?

    I am very comfortable expressing myself in ASL.
    a. Strongly disagree
    b. Disagree
    c. Neutral
    d. Agree
    e. Strongly agree

8. How much do you agree/disagree with this statement?

   I am very comfortable reading in English.

   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

9. How much do you agree/disagree with this statement?

   I am very comfortable writing in English.

   a. Strongly disagree
   b. Disagree
   c. Neutral
   d. Agree
   e. Strongly agree

Appendix I: Authorship Table

1 Introduction	
1.1 Motivation	Juliana Porto, Julia Albrecht, Jenna Tripoli
1.2 Project History	Julia Albrecht, Jenna Tripoli
1.3 Problem Statement	Juliana Porto, Julia Albrecht, Jenna Tripoli
2 Background	
2.1 American Sign Language	Juliana Porto
2.2 Sign Language First Technology	Juliana Porto
2.3 SL1 Survey Tools	Juliana Porto, Julia Albrecht
3 Previous Work	
3.1 Initial Research into ASL Surveys	Jenna Tripoli
3.2 Survey Tool Designing and Prototyping	Jenna Tripoli
3.3 Continued Survey Tool Implementation	Jenna Tripoli
3.4 Design Contributions from the AEC	Jenna Tripoli, Julia Albrecht
4 Project Goals	
4.1 Stakeholder Analysis	Juliana Porto
4.1.1 Deaf Community Members	Juliana Porto
4.1.2 SL1 Technology Researchers	Juliana Porto
4.2 Application Requirements	Juliana Porto
4.2.1 User Interface Requirements	Juliana Porto
4.2.2 Functionality Requirements	Juliana Porto, Jenna Tripoli
4.2.3 Prioritizing Requirements	Juliana Porto, Jenna Tripoli
5 Methodology	
5.1 Agile Development	Juliana Porto
5.2 Technology Stack	Juliana Porto
5.3 External Programs	Jenna Tripoli
5.4 Team Meetings	Jenna Tripoli

6 Implementation	
6.1 Minimum Viable Product	Jenna Tripoli
6.2 Video Shape, Sizing, and Layout	Jenna Tripoli
6.3 Colors and Indicators	Jenna Tripoli
6.4 Final Application	Jenna Tripoli
7 Evaluation	
7.1 Evaluation Metrics	Juliana Porto, Jenna Tripoli, Julia Albrecht
7.1.1 Application Functionality	Juliana Porto, Jenna Tripoli, Julia Albrecht
7.1.2 User Experience	Jenna Tripoli, Julia Albrecht
7.2 User Testing	Jenna Tripoli
7.2.1 Study Procedures	Jenna Tripoli, Juliana Porto
7.2.2 Design Process	Jenna Tripoli
7.2.3 Participant Demographics	Jenna Tripoli, Juliana Porto, Julia Albrecht
7.3 Data Analysis	Juliana Porto, Jenna Tripoli, Julia Albrecht
8 Results	
8.1 Application Functionality	Jenna Tripoli
8.2 User Experience	Juliana Porto, Jenna Tripoli, Julia Albrecht
9 Discussion	
9.1 Design of the SUS Survey	Julia Albrecht, Jenna Tripoli
9.2 Introduction Video Clarity	Julia Albrecht, Jenna Tripoli
9.3 Positive Anecdotes	Jenna Tripoli
10 Future Work	
10.1 Quantitative Metric Collection	Juliana Porto
10.2 Administrative Features	Juliana Porto, Jenna Tripoli, Julia Albrecht
10.3 Survey Functionality	Juliana Porto
11 Conclusion	Jenna Tripoli, Juliana Porto, Julia Albrecht