"Signifier" Video Sharing Platform and Accessible Media Player for Deaf Users

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ABSTRACT

With technology for social good at the forefront of this work, we present a platform demonstrating the use of inclusive and accessible IT for education and other domains. The design and development of video sharing platform, "Signifier" is discussed, with particular focus on the integrated "Signifier" Accessible Media Player (SiAMP), supporting sign language integration during video play. SiAMP was evaluated with six sign language users: three native American Sign Language (ASL) users and three native Cypriot Sign Language (CSL) users. ASL was selected in the first implementation of the platform because it is a popular sign language, used daily by about five hundred thousand people in the US. Moreover, ASL users also tend to be early adopters of new innovations in IT for the Deaf community, making them more ideal testers to collect feedback from during evaluations. In lieu of the research and development being conducted in Cyprus, it was equally important to collect feedback from participants of the local Deaf community as well, even though SiAMP was designed with ASL users in mind, at this stage. SiAMP offers four functionalities to increase user-friendliness, user experience (UX) and accessibility, adapting to the needs and preferences of its users, namely captions with English alphabet text, ASL fingerspelling, video with sign language interpretation and signwriting alphabet.

CCS CONCEPTS

• **Software and its engineering**; • **Software creation and management**; • **Designing software**; • **Software design engineering**; • **Social and professional topics**; • **User characteristics**; • **People with disabilities**;

KEYWORDS

media player, accessible, sign language, inclusive design, UX

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1 INTRODUCTION AND BACKGROUND

Web accessibility means people, regardless of ability, can perceive, understand, anticipate, and interact with the web [1]. For many who are Deaf however, online media content and IT prove problematic to use [2]. Also, the first language for many is their country's native sign language and not the spoken one [2, 3]. Providing information in sign language can alleviate accessibility barriers and impact their UX and inclusion positively [2]. It is estimated that about 0.1% of the population in any given country are deaf and use sign language [4]. Furthermore, the UN reports that there are 300+ different sign languages worldwide [5], with ASL being one of the most popular and used by around five hundred thousand people in the US alone [6].

Most of the information and services users seek daily is available online, making it imperative to ensure that everyone has equal access to it. To safeguard this right, the EU has introduced the Web Content Accessibility Guidelines (WCAG) [7][8], while the US has enacted Section 508 [9]. While there is research on the barriers of online media content and approaches to overcome them on impairments such as blindness [10], research for the Deaf and Hard-of-Hearing (D & HH) user group is limited. Certain media content, such as videos used on many websites, is not optimised for accessibility. Hence, video media and other media content may not be fully inclusive to experience. Regarding video media particularly, the D & HH user group, comprising almost 20% of the world's population [11], are directly affected. Non-accessible online media content, including videos, is thus difficult to use for this user group.

Research in [5] focused on users who are blind and stresses that accessibility in media content (e.g. video captions and alternative descriptions) impacts on the interaction of people with other types of disabilities as well. Another study [12] reports on an online survey administered to a large sample of D & HH participants and explored which genres of online video media they believed were important to be accurately captioned. This work looks at how D

& HH viewers perceive the importance of captions for different online video media genres. Findings support future efforts in the creation of datasets of online videos, to be used for training and evaluating captioning technologies purposes.

Website accessibility is also a general concern and challenge for most D & HH users. Common barriers are audio content (e.g. videos with voices and sounds without captions or transcripts and media players without captions or volume controls) [13]. Other concerns include the use of automated subtitles, often inconsistent with the words of the narrator in the video and having a non-discrete sign language interpreter. Functionalities for video audio translation also tend to be limited, e.g. use subtitles or sign language interpreter only.

The scarcity of research on accessible video media for D & HH users is evident. Regarding the entire disability spectrum, the research support action on Media Accessibility, i.e. the Leading Platform for European Citizens, Industries, Academia and Policymakers in Media Accessibility (LEAD-ME) Cost action [14], stands out. Acknowledging the extent of the problem, it aims to guide stakeholders in the field of Media Accessibility and enable stakeholders to utilise a common and innovative platform which will collect, create, and disseminate innovative technologies, solutions, best practices and guidelines on Media Accessibility. It pursues the fruitful collaboration of these stakeholders in contributing to existing standards and guidelines and proposing new ones in Europe [15]. In summary, it focuses on a technical platform that allows a single point-of-access to relevant technologies, guidelines and curricula for teaching and training, quality and standardisation and status-quo and future directions of Media Accessibility [16]. It is a promising action for the field in general.

In this paper, we present the "Signifier" video sharing platform and "Signifier" Accessible Media Player (SiAMP). This aims to enhance the accessibility and UX of D & HH users when interacting with video media. It was designed and developed having educational video media in mind but can be used broadly for video media outside of the educational scope. In terms of the educational context, we envisage SiAMP as an integrated solution to e-learning platforms, to offer accessible video media learning content (e.g. recorded lectures) to learners who are deaf. Section 1 continues with comparing existing media players and defining the research gap that initiated this work. Section 2 describes the methodology, while Section 3 presents the "Signifier" video sharing platform and SiAMP from a technical perspective. Evaluation results are presented and discussed in Section 4. The paper concludes and lists future work opportunities in Section 5.

1.1 Media Players Comparison

Table 1 compares the most recent and relevant media players to SiAMP. These were selected via literature review and feature analysis. Analyzing the design and technical characteristics of similar solutions helped to explore the current intersection between theory-driven accessibility and practical implementation. It also helped in designing and developing the "Signifier" video sharing platform and SiAMP. It particularly guided the transfer of theoretical knowledge and drawing on practical applications observed or lacking thereof in the design of popular media players.

Following this comparison, it can be concluded that available functionalities of existing media players do not fully cover the needs of the D & HH user group. It is crucial to thus develop media players with various functionalities that are accessible to all users. SiAMP was designed with this purpose, as it enables users to control and adjust the media payer with the provided functionalities. A customized media player that serves various viewing styles for D & HH users highlights the contribution of this work.

1.2 Research Gap

Following a literature review and an exploration of existing IT solutions, it was determined that D & HH users experience accessibility barriers when using media players on websites and web platforms. This is due to the lack of appropriate functionality for them to make video media content more accessible. Media players that do consider this aspect are still very limited in terms of their

Table 1: Comparison of functionalities offered in popular media players to enhance accessibility

Functionalities	YouTube	Vimeo	Dailymotion	Able Player[1]	Video.js[2]	SiAMP
Automatically play of video when selected		√			√	√
Adjust sound	√	√	√	√	√	√
Reposition video		√	√	√	√	√
Adjust video speed	√	√	√	√	√	√
Activate subtitles on video						√
Adjust size and background colour of subtitles				√	√	√
Activate video with sign language interpreter						√
Enlarge video with sign language interpreter						√
Reposition video with sign language interpreter						√
Activate "fingerspelling" subtitles						√
Activate "fingerspelling" subtitles with letters						√
Activate "signwriting" subtitles						

[1]Able Player media player: https://ableplayer.github.io/ableplayer/
[2]Video.js media player: https://videojs.com/

functionality offerings. More research is hence needed to first understand what functionalities could be offered to further improve the UX and accessibility for this user group and second, whether using a combination of functionalities in tandem is helpful. This led to the designing of SiAMP, an accessible and inclusive online media player, integrated into the "Signifier" video sharing platform that provides multiple functionalities to users when watching video media content. To achieve a better UX, users can select from functionalities such as captions in English alphabet, ASL fingerspelling, video with sign language interpreter and subtitles in signwriting alphabet.

2 METHODOLOGY

To employ a systematic approach during the technical design and implementation, the waterfall model was followed, consisting of several stages:

- **Designing the mid-fidelity prototype**. Before development could commence, a mid-fidelity prototype was designed using the Justinmind prototyping and wireframing tool, in order to present SiAMP's interactions and navigation capabilities. It was evaluated by three HCI experts and recommendations for improvements were reported.
- **Developing "Signifier" video sharing platform and SiAMP**. For the platform's front-end development, html5, JavaScript and CSS were used; PHP was used for the back-end. MySQL was used for management and data organisation.
- **Evaluating SiAMP**. Three users who are deaf from the US, who use ASL as a first language, and three users who are deaf from Cyprus, who use CSL as a first language, participated in the evaluation. Feedback was collected using an online survey and was considered to further improve the design of SiAMP, via a new iteration cycle.
- **Optimising and maintaining.** Updates and overall maintenance are done to the "Signifier" video sharing platform and SiAMP during this stage. This remains an ongoing process.

In this systematic approach, several research methods were employed for data collection. Prototyping (stage 2) is utilised in the early stages of design to test the functionalities and layouts of a user interface before development begins [17]. A design's fidelity (i.e. low-, mid-, high-) describes the level of detail and functionality incorporated into a prototype. It thus varies in terms of interactivity, visuals, content and commands, and other areas. Expert reviews (also stage 2) is a usability inspection method conducted by field experts, requiring them to use their practical skills and theoretical knowledge of guidelines and standards to evaluate a design's conformance. It allows for a quick, cost-effective, and easy evaluation of a user interface design [18]. With three to five experts, an average of 75% of usability problems can be discovered [18]. In stage 4, an online survey (a Google form collecting quantitative and qualitative data) with the SiAMP demonstration video was designed and used as the evaluation instrument for users to share feedback. Descriptive statistics were then used to analyse the data. The 5-point Likert scales mainly used measured frequency and helpfulness. Other scales used to a lesser extent included 5-point Likert scales on the levels of similarity, difficulty and confidence. There were also two paired comparison scale questions, two forced ranking scale questions and two open-ended questions.

3 "SIGNIFIER" VIDEO SHARING PLATFORM

Here, the "Signifier" video sharing platform and SiAMP are presented. First the system architecture is discussed, followed by the functionalities offered in SiAMP. A discussion on the W3C Guidelines considered in the design and development of SiAMP concludes the section.

3.1 Architecture

The two primary components of the architecture are the front- and back-end. The front-end includes the user interface while the back-end includes the media player processing functionalities. The user uploads the main video link and the video link with the sign language interpreter to a video hosting platform with the respective subtitle file (in ". vtt" format), henceforth stored in the database. Specifically, there is a page for uploading both and the user can provide metadata such as description, title and video category. Both videos need to be recorded before for this stage. The aim is for the sign language interpreter video to be auto-generated from SiAMP in the future. When the user selects to view a video, the link to the video, the subtitle file, and the video with sign language interpreter are all loaded from the database to the SiAMP page. Subtitles using ASL fingerspelling and signwriting are automatically generated based on the text subtitles at the given time, with the use of images from the corresponding file. The difference between signwriting and fingerspelling is that for signwriting, visual symbols are used to represent the handshapes (see Figure 5) while in fingerspelling, letters of a writing system are represented using only the hands (see Figure 4).

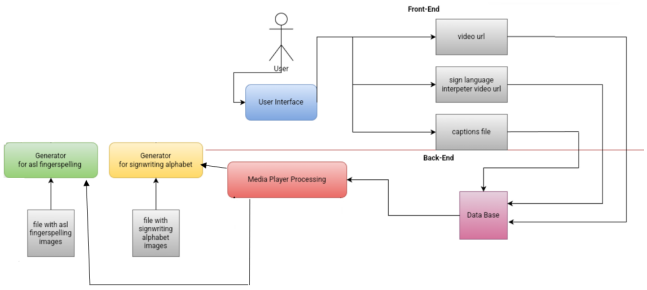

Figure 1: The architecture of the "Signifier" video sharing platform.

3.2 Functionalities

SiAMP offers the following functionalities to the user, which can be enabled when desired.

Menu and Captions (see Figure 2): The user activates ASL subtitles, captions, sign language interpreter and signwriting by clicking the respective button of the menu, which is located on the top of the page. The user activates the subtitles by clicking the "Captions" button; these will then appear. Font size, font color of the captions, and the background color can all be selected.

Figure 2: Menu with the functionalities of SiAMP and activating and adjusting captions.

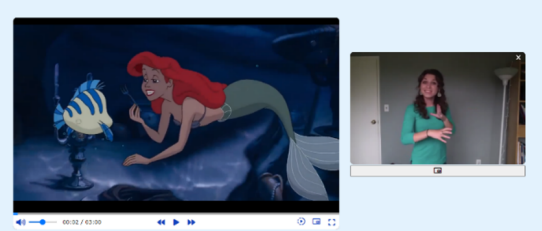

Figure 3: Activating and repositioning the video with sign language interpreter.

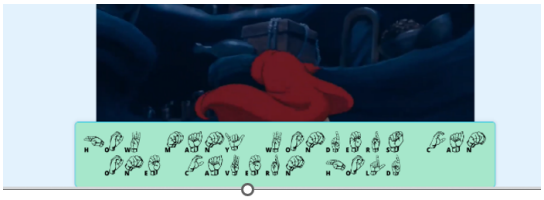

Figure 4: Activating ASL fingerspelling subtitles with English alphabet.

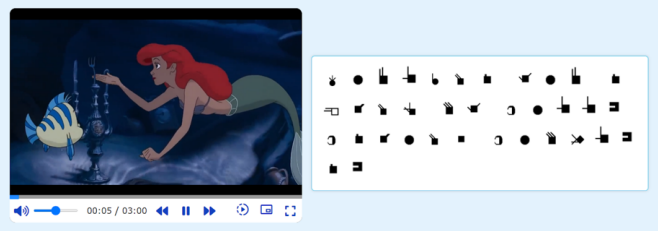

Figure 5: Activating signwriting.

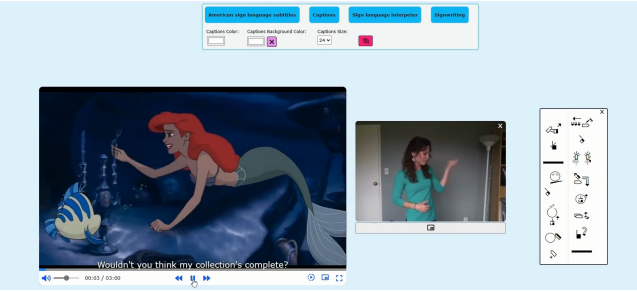

Figure 6: Activating a combination of functionalities: captions, sign language interpreter video and signwriting.

Video placeholder for sign language interpreter video (see Figure 3): The user activates the video with the sign language interpreter by clicking the "Sign language interpreter" button; it will then appear on the screen as a separate video from the main video. The user can reposition the sign language interpreter video on the page by activating the picture-in-picture mode and increase its size.

ASL fingerspelling (see Figure 4): The user activates the subtitles with the ASL alphabet by clicking the "American sign language subtitles" button. The user can also adjust the background color of the subtitles and display letters of the English alphabet in combination with the ASL alphabet.

Signwriting (see Figure 5): The user activates subtitles with the signwriting by clicking the "Signwriting" button.

Combination of functionalities (see Figure 6): The user can activate all functionalities together or select ones which are more convenient/helpful. Selecting more than one can allow for a personalised viewing experience that meets their needs at the time.

Regarding scalability, SiAMP could be further developed to support a wider range of sign languages. For instance, incorporating Cypriot Sign Language (CSL) and other regional sign languages, such as British Sign Language (BSL), French Sign Language (LSF), and Japanese Sign Language (JSL), would ensure SiAMP caters to a more global audience. This requires that the fingerspelling alphabet of the country be designed and integrated with its signwriting (if existing). Video, subtitles and sign language interpreter video will need to be uploaded on the platform. This expansion would not only support the D & HH communities more effectively but also promote linguistic and cultural diversity in digital content consumption.

3.3 W3C Guidelines Considered

The literature review process particularly considered W3C guidelines relating to the use of subtitles and sign language interpreter. SiAMP was designed and developed following W3C guidelines to explore how helpful each functionality is to users and the usefulness of simultaneously using a combination of functionalities. Most guidelines have been considered in the current version of SiAMP. Those not yet considered would need to be further explored and considered, if applicable, in an updated version of SiAMP.

Regarding W3C guidelines for subtitles, SiAMP has considered 14/28 guidelines, including erasures, gap-less cues, multiple text cues at the same time and explicit line breaks, among others. Guidelines not yet considered included positioning on all parts of the screen, displaying of multiple text cues also in ltr or rtl languages and allowing a range of font faces, among others. Regarding W3C guidelines for sign language interpreter, SiAMP has considered 4/5

guidelines including supporting sign-language videos and supporting the synchronized playback of sign-language videos. The one guideline not yet considered was supporting multiple sign-language tracks in several sign languages. Looking forward, the aim should be to explore how to comply with the remaining guidelines but this also depends on functionality offered.

Overall, SiAMP provides comprehensive support for sign language content, enabling users to include sign language videos as tracks within the media resource or as external files. It ensures synchronised playback of sign language videos with the main media content, offering various display functionalities such as picture-in-picture, alpha-blended overlay, and parallel video playback.

4 RESULTS AND DISCUSSION

SiAMP was evaluated through an online survey. A demonstration video[1] of SiAMP was also embedded. The survey was disseminated to the D & HH communities of Cyprus and the US, in Greek and English respectively. The Nicosia School for the Deaf helped with the recruitment of participants in Cyprus, while AnnRae Consulting[2], a certified Deaf interpreting organisation, with recruitment in the US.

Regarding the frequency of using video sharing platforms, two out of three respondents from the US indicated daily usage, with the remaining one reporting weekly engagement. Conversely, only one in three respondents from Cyprus reported daily usage, one indicated weekly usage and one reported infrequent usage. Results align with the notion that the US D & HH community is more likely to engage and adopt innovations in IT that will impact their lives compared to other D & HH communities worldwide. This further supports our reasoning on designing for ASL in the first implementation of SiAMP.

Regarding the question "*How frequently do video sharing platforms include a sign language interpreter when you are watching a video?*", two US respondents indicated that a sign language interpreter is rarely present, while one reported it to be hardly ever the case. From Cyprus, one in three stated that a sign language interpreter is always included, one indicated an interpreter to be present most of the time, while one specified occasional inclusion. This data highlights a notable disparity in the provision of sign language interpreters between the two samples. The responses from the Cyprus users may be misleading though, in that they tend to consume video media content that was specifically created for them by the community itself and uploaded to video sharing platforms. It does not necessarily mean that any video media content they would like to view in general, nor created for them specifically in CSL, provides sign language interpretation *per se*.

With regards to subtitle or caption frequency within videos, responses between the samples were similar, as two out of three respondents from both the US and Cyprus indicated occasional inclusion, while one reported intermittent presence. It is hence perceived that most of the videos viewed by respondents from either sample feature subtitles or captions, albeit inconsistently.

For the question "*How frequently do you utilise the autogenerated subtitles/captions setting on video sharing platforms?*", there were also similar responses between the samples: two in three from each group indicated occasional usage, while one reported intermittent use. It is thus perceived that most of the videos viewed by respondents are equipped with subtitles through auto-generation, albeit inconsistently. In assessing the efficacy of the sign language interpreter feature of SiAMP, respondents were asked to rate its helpfulness on a scale of 1 to 5, with 5 indicating the highest level of utility. All US respondents perceived the sign language interpreter to be extremely useful. For the Cyprus respondents one in three opted for a similar rating, one provided a rating of 4, while the other respondent provided the lowest rating possible (1). Most responses align with research-based evidence suggesting that the sign language interpreter functionality is expected to be the most desired one by users.

Responses on the usefulness of captions while watching a video show that all participants from both samples selected the highest level of utility. It can hence be inferred that the use of subtitles is universally perceived as particularly advantageous by users during video consumption. It should be noted that this has been the most used and available functionality to date, other than sign language interpreting videos, which are mostly created by the D & HH community for the community itself and represents a fraction of the video media content available on video sharing platforms. For this reason, we believe it was highly rated, since there are no other alternatives. Literature indicates that the literacy skills of persons who are deaf tend to be poor [2], bringing into question their capability to read captions timely and understand them completely. Thus, one of the aims of this work is to explore other alternatives, i.e. functionalities of SiAMP, and discover whether they can be useful under any conditions.

For the question *"Do you prefer to have more than one option together?"*, two thirds of respondents from both the US and Cyprus indicated a preference for having multiple functionalities used together, while the rest expressed a contrary perspective. Moreover, among US respondents who favored multiple-functionality use, the combination of sign language interpreter and captions was deemed as being the most useful function. Respondents from Cyprus preferred all functionalities used together as the most beneficial option when watching a video. Notably, respondents were asked to prioritise, in order of preference (i.e. forced ranking scale question), the most useful features to them. Yet only their preferred option was submitted. This could be attributed to either their genuine preference for a singular functionality combination or a potential misunderstanding of the task.

Regarding the utility of ASL subtitles while watching a video, most respondents expressed a non-significant utility for this feature. All US participants and one in three from Cyprus indicated the lowest rating available (1), hence perceiving the function as not at all useful. One Cypriot respondent rated the function as not useful, while the remaining respondent rated the function as extremely useful. It would be interesting to follow up on whether ASL subtitles could be of use on specific video media content, e.g. a short duration video of a few seconds, like in adverts, or when displaying telephone numbers, or the name of products and suppliers.

[1]SiAMP demonstration video: https://drive.google.com/file/d/11HVRe3FORMGJ1-douGh4kUeiSmjxU09d/view.
[2]AnnRae Consulting website: https://arclingui.com/.

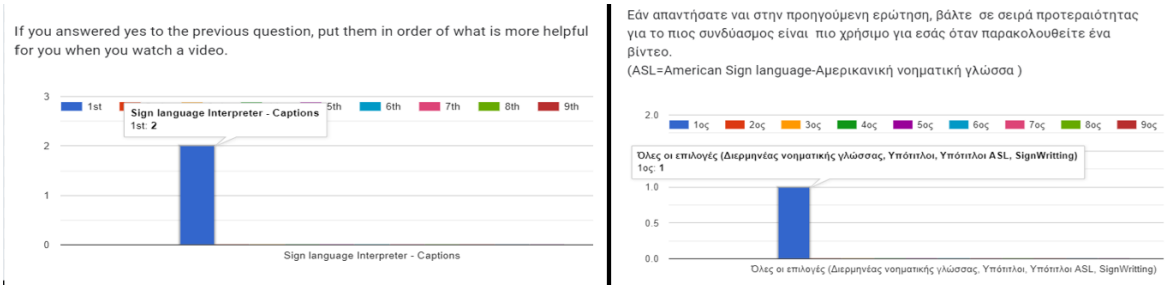

Figure 7: Preferences on multiple functionalities use by US and Cyprus respondents respectively (the Greek question is a direct translation of the English question).

On the utility of SignWriting while watching a video, there was great disparity between the samples. All US respondents perceived the feature as not at all useful. On the contrary, one Cyprus respondent rated the utility as useful, while the other two respondents rated the function as extremely useful. This finding would need to be further explored and considered in a SiAMP version for CSL.

Among US respondents who indicated a preference for singular functionality, sign language interpreter was the most favored option, while ASL subtitles were the least favored one. Conversely, Cyprus respondents had subtitles as the most useful functionality and sign language interpreter as the least preferred one. This reflects divergent preferences regarding what is most useful to users when watching videos. However, it also contradicts the responses from Cypriot users on the question regarding the efficacy of the sign language interpreter feature of SiAMP, where the consensus was that this functionality is valuable to them as well. This requires further discussion with CSL users.

Having in mind a consistent and familiar design to improve learnability, for the question "*Does the design of the media player look similar?*", a single US respondent indicated that the design closely resembled other media players, another suggested an intermediate level of similarity while one respondent indicated that the design was not reminiscent of similar media players at all. Conversely, two Cyprus respondents denoted a design that did not resemble similar media players while another suggested an intermediate level of similarity. It can therefore be inferred that for Cyprus respondents, the design did not have a similar look and feel to other media players. Responses could be attributed to the lack of IT use in general. Further investigation is needed here as well. Having in mind usability, for the question "*Does the media player look easy to use?*", two US respondents indicated that SiAMP appeared very easy to use, while the remaining respondent noted an intermediate level of ease. Conversely, a single Cyprus respondent indicated that SiAMP was very easy to use, another indicated an intermediate level of ease, while one indicated that SiAMP did not appear easy to use at all.

On the question of whether respondents would need any help during their experience with SiAMP, all US respondents indicated they would not require assistance in using SiAMP, which correlates to their responses on the ease of use of SiAMP. From Cyprus, a respondent indicated they would not require assistance in using SiAMP, another stated they would require help, and one indicated they might need assistance. Therefore, while all US respondents expressed self-sufficiency in using SiAMP, this was not the case for Cyprus users. This again highlights the difference between the two communities with regards to IT exposure. Lastly, for the question "*Would you be confident using the media player?*", one US respondent indicated a high level of confidence in using SiAMP, while the other two signified a substantial degree of confidence. Two Cyprus respondents also indicated a high level of confidence in using SiAMP; however, one respondent provided the lowest rating possible (1), indicating a lack of confidence in using it. Overall, most respondents from both groups exhibited a high level of confidence in using SiAMP.

5 CONCLUSION AND FUTURE WORK

"Signifier" video sharing platform and SiAMP represent a step forward in addressing accessible online video media content for D & HH users. SiAMP supports captions in English alphabet, ASL fingerspelling, video with sign language interpreter, and subtitles in signwriting. Six participants who are deaf from the US and Cyprus evaluated it and shared insights on their preferences and usage patterns. Results indicate varying degrees of availability and usefulness of accessibility features across different video sharing sites and highlighted the importance of providing multiple functionalities to accommodate diverse user needs and preferences, which SiAMP strives for.

The main limitations of the study were a small sample size, which affects generalizability of findings, and having CSL users evaluate the ASL version. In respect to this, we emphasise the significant effort devoted to recruiting participants from both groups. Recruiting participants without assistance from those inside the communities is challenging. Moreover, although SiAMP is designed for ASL users, CSL users were pleased to participate, and share their opinions on the respective functionality for CSL users.

Areas for improvements of SiAMP are evaluating it with larger sample sizes, using sign language on its user interface and the platform, adding additional sign languages, integrating avatar-based sign language interpretation, exploring machine learning/AI methods for automated sign language translation and examining user preferences for specific video categories. By incorporating these advancements, SiAMP can further enhance its accessibility and inclusivity, ensuring that D & HH users can fully participate in, and benefit from, online video media content.

To conclude, SiAMP represents a significant step forward in promoting web accessibility and inclusive design principles. By prioritizing the needs of diverse user groups and leveraging advanced technologies, SiAMP contributes to creating a more inclusive online environment where all users, regardless of ability, can equally access and experience digital video media content.

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