Distance Meetings During the Covid-19 Pandemic: Are Video Conferencing Tools Accessible for Blind People?

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ABSTRACT

Since the first lockdown in 2020, video conferencing tools have been becoming increasingly important for employment, education, and social interaction. This makes accessibility and usability of these tools particularly For instance, are the main functionalities dully accessible to all users? In this study we analyzed their usage by screen reader and keyboard, which is the main interaction modalities used by the visually-impaired people. An inspection evaluation was applied to test the most important features and a survey of visually impaired users was been carried out to obtain preliminary information about the accessibility of three commonly used video conferencing tools. The study found that the popular video conferencing tools Zoom, Google Meet and Teams are not fully accessible via keyboard and screen reader. However, Zoom was preferred tool to Google Meet and Teams.

CCS CONCEPTS

• People with disabilities; • Human-centered computing~Accessibility design and evaluation methods • Human-centered computing~Accessibility technologies • Web-based interaction; Empirical studies in accessibility

KEYWORDS

Videoconferencing tools; blind people; screen reader, screen reader users; accessibility

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1 Introduction

The Covid-19 pandemics has had a significant impact on most everyday life. The need for physical isolation has moved many activities online, including those related to employment, education, some aspects of health care, and social interaction. Face to face meetings have largely been replaced by video conferences, online chats and instant messaging. In particular, many people are now using video conferencing tools, including Skype, Google Meet, Teams and Zoom, on a regular basis. However, this rapid move from face to face to online activities has led to problems for people with limited computer skills and many older and disabled people. Accessibility and usability are essential for ensuring effective and painless use of these technologies by all potential users and that particular groups such as disabled people are not excluded from participation. Thus disabled people need to be able to access and use these tools easily and effectively in order to have equal opportunities to (continue to) study, work and engage socially. This paper is focusing on the needs of blind people, due to the increased time and cognitive load of online tasks when using a screen reader [Ivory et al., 2004].. They may experience particular challenges in downloading, setting up and configuring the required software, and being able to use all video conferencing tool functions.

In this study we investigate the user experiences of blind users when interacting via screen reader and the online interface of three popular video conference tools. This included inspection evaluation and analysis by accessibility experts are applied of tool use via screen reader and keyboard. This was followed by a survey using Google Forms to investigate the experiences of blind users and any resulting accessibility and usability issues.

The paper discuss discuses the results of accessibility inspection evaluation and a survey of three popular video conferencing tools: Zoom, Teams and Meets when used by blind people with a screen reader. The main contribution of the paper is the identification of accessibility and usability issues

for blind people interacting with video conferencing tools via screen reader.

The paper is organized into 6 sections. Section 2 briefly discusses the relevant literature and section 3 presents the methodology and the criteria applied in the inspection. Section 4 and 5 respectively present and discuss the results with conclusions in section 6.

2 Related Work

Blind people can miss important information and communication when this is provided in purely visual form. When analyzing accessibility of meetings for blind people, it is important to note that meetings include visual content and nonverbal communication elements such as gestures, facial expressions and dynamic changes of focus on objects (Pölzer et al. 2013). Pölzer et al. have investigated making visual tools for brainstorming accessible and detection and delivery non-verbal communication cues. This is important for both face-to-face and on-line meetings.

Research on the accessibility of video conferencing tools is still in its infancy. Videoconferencing platforms include a set of tools which are intended to function together seamlessly, but do not necessarily do so when used by blind or other people. These sophisticated environments offering a wide range of functions (such as muting/unmuting microphone, turning video on/off raising hand, sharing screen or files and playing video). The design of these tools has not necessarily considered the diversity of users and modes of access. Thus blind people may experience difficulties with 1) exploration and navigation, i.e. moving rapidly between different areas and tools, and 2) proficient and speedy use of available functions such as hosting a meeting, adding participants, accepting a meeting invitation and controlling devices such as speakers and video-camera. The available tools for navigation and exploration include access Keys, Tab keys, and screen reader commands.

In educational environments Learning Management Systems have developed from static tools to include live virtual classrooms which enable remote face-to-face interactions. Examples include the inclusion of Zoom in Moodle and Google Classroom. Business and organisational environments have progressed from groupware systems to video conferencing tools, such as Zoom.

It is the Covid-19 pandemic and the associated periods of lockdown and need to carry out activities at a distance which has led to the widespread global use of these tools in many different contexts, including employment and education and a wide range of everyday activity This has also increased the importance of full accessibility and usability of these tools, which include MS Teams (that improved and replace Skype for Business), Google Meet and Zoom. In educational context cloud-based learning environment are increasingly popular with pedagogical benefits (Morquin et al., 2019). Tools such as Zoom enable students to interact with professors and classmates via smartphones, tablets and/or computers. Best practices for delivering lessons and support learning via virtual classroom are proposed by (Barbosa, & Barbosa, 2019).

The small number of existing studies indicate that videoconferencing system are not fully accessible. For instance research states that popular chat systems such as WeChat, Hangouts, Tango, Line and Viber are not fully accessible for the blind (Maneesaeng et al., 2016). A preliminary study on accessibility of main popular video conferencing tools for people with disabilities is carried out in [Hersh et al., 2020]. However, this study addresses multiple disabilities, while a more systematic study is necessary involving blind people to better understand their needs as well as understand their suggestions in order to be able to advance new proposals. To the best of authors knowledge, in literature there are not studies in this field. However no-scientific empirical studies and basic suggestions by professionals or associations for the blind can be found on the net. Our study tries to put a little step ahead in this direction.
When analysing online videoconferencing tools, it is crucial to understand how functions and the visual graphic interface can be managed via screen reader. In the following a methodology for analyse videoconferencing tools is introduced.

3 Evaluation Design

A preliminary study of the three popular videoconferencing tools, Zoom, Google Meet and Teams, was carried out by the authors in order to obtain a first evaluation of their accessibility features for screen reader users. Most of these tools offer both desktop and mobile versions which have different operating systems and so require different commands and interaction via assistive technology. The current study relates to the desktop versions of Zoom and Teams and the web-based version of Google Meet, as it does not have a desktop version. This was followed by an online questionnaire.

Inspection evaluation can help designers to identify areas of the design that need particular focus. In particular, it can contribute to (a) highlighting tasks that users are likely to have difficulties in completing, and (b) identifying interface components that may require attention to assure a good interaction. In this study the inspection evaluation focused on identifying the crucial tasks in which a screen reader user may encounter difficulties. An online questionnaire was

subsequently used to verify and extend the results of the inspection evaluation and investigate the specific experiences of end-users and obtain their suggestions for improvement.

The inspection evaluation was carried out by two of the three authors. All the authors have good knowledge of accessibility and usability of user interfaces for blind people. One of the authors has been totally blind since childhood and is expert in using a screen reader. The screen reader Jaws for Windows 2021.2012.48 was used to interact with the user interfaces.

3.1 Inspection Analysis

The first stage of the inspection analysis involved identification of critical aspects of the interaction and the tasks and activities that users were required to perform.

Video conferencing provide users with two main roles:

a) Host: the person who creates and manages the online meeting. Hosts include teachers and tutors who set up and facilitate online learning activities with groups of students, including lectures, classes and group work on particular activities, and the organiser or convenor of a group of participants when the tool is used in meetings and conferences. Hosts also include students who organise online learning (or social) activities for themselves and their teachers as part of active learning.
b) Participant: participants engage in meetings set up and chaired by others. They include students taking part in online learning activities and participants and collaborators taking part in a wide range of meetings and conferences.

In this preliminary study, only the basic functionalities have been considered for the 'Participant role'. The more advanced 'participant' functions and the 'host' functions will be considered in a further evaluation. The following participant functions necessary to use a video conferencing tool effectively were considered:

(1) using the input devices (turn on/off); (2) access to status (e.g. check which devices are on/off or obtain information about the other participants); (3) active participation (e.g. comment orally, share screen content, and read/write chat messages). The user should be able to obtain various data and access the tool' status. This is relatively easy to do for non-disabled users who are able to obtain the information visually from the interface, but may be more difficult for screen reader users. Hence, this paper is investigating accessibility via screen reader and the tasks that can be carried out relatively easily using a keyboard. Subsequent sections next sections more details will be provided about the tasks and functions considered in this study.

To test the interaction via screen reader and keyboard, we carried out the following procedure for each function:

- Use of the Tab key and Arrow keys to move the focus onto the function and explore the user interface and enable us to analyze screen reader behavior when handling the focus.
- Applying the shortcuts available in the user interface to test the use of shortcuts to activate the given function.
- Using screen reader commands for specific actions to get information on the user interface and function feedback (which non-disabled users generally obtain from viewing the screen). This was used when the focus did not work, there was no shortcut or it did not work.
- Analyzing the clarity and relevance of the screen reader feedback messages, both when using the Tab key to move the focus and using shortcut keys.

Particular attention was given to the screen reader feedback messages provided to the user, as blind people need to be able to perceive what is happening and obtain visual information via screen reader or Braille display (Borodin et al., 2010). For instance, when evaluating information about microphone status, a message like "Turn on the microphone" as the label for the microphone status button and read by the screen reader can be considered adequate to inform the user that the microphone is currently off. However, the microphone button label "Activate/disactivate" could be ambiguous and provides less clear information about the microphone status.

3.2 Survey

An online questionnaire was drawn up to investigate further accessibility and other issues identified by the inspection evaluation. The questionnaire had 18 questions grouped in three sections:

I. user demographic data: five questions
II. tool use: a separate subsection for each tool to make with four questions in each subsection. This organization was intended to make it easier to focus on the particular tool.
III. comments and suggestions: a single question asking for comments, descriptions of issues and suggestions for improving the three tools.

Simple language was used and the questions were formulated to make them easily memorisable with the Likert scale at the end to make them more accessible with a screen reader.

The questionnaire was made available as a web-based form using the Google Docs suite (https://docs.google.com/). It was piloted with two blind people before being distributed throughout the visually impaired community in Italy via email to general and specific mailing lists of the Italian Association for the Blind.

To facilitate questionnaire use via screen reader, the questionnaire title was tagged with an HTML H1 heading

element and each section with an H2 heading element. This allowed users to use key presses (e.g., "h" for the Jaws screen reader) to move to the next or previous question and immediately listen to the question number. The question title was kept short, to avoid annoying the user by repeatedly reading long heading elements. The navigation structure enables the user to quickly reach each question and read only its number and a very short description; they can then read the whole question by using the arrow keys. Users can move directly to the next question by pressing the command key after answering t he previous ones. All the questions were optional. This reduces the stress of users having to find missing answers, though could risk some relevant questions not being answered.

3.3 Tool Functions

The functions considered in the evaluation are listed in table 1. They have been classified as 'action' tasks i.e. actions related to active tasks such as turning on/off the microphone or video camera; and 'awareness' tasks which mainly involved status checking activities, such as the on/off status of the microphone or video camera.

Table 1: Tasks considered in the evaluation

Type	Description
Action	F1. Joining a meeting
Action	F2. F2. Raise hand (Asking to speak in a meeting)
Action	F3. Turning the microphone on/off
Action	F4. Turning the video camera on/off
Action	F5. Audio, video, file and screen sharing
Action	F6. Using the chat
Awareness	F7. Accessing the shared content
Awareness	F8. Check the microphone and video camera status
Awareness	F9. Participant information (number, names, who is joining or leaving)

4 Results

Survey results were obtained from 29 blind people. Comparison of these results and those of the inspection evaluation shows full agreement on the main issues observed. Tables 2, 3 and 4 summarize the results of the inspection evaluation for Zoom, Google Meet and Teams respectively. For each function the table indicates whether (1) the focus is supported, (2) there is a shortcut for the function, (3) the screen reader (SR) feedback is appropriate. The * symbol indicates that the function is fully accessible, the + symbol indicate a partial accessibility and the empty cell state for a function inaccessible. In the following some comments and more details are reported.

Table 2: Inspection evaluation of Zoom accessibility features

Function	Focus	Shortcut	SR feedback
F1. Joining a Meeting	*		*
F2. Hand Raise	*	*	*
F3. Turn mic on/off	*	*	*
F4. Turn cam on/off	*	*	*
F5. Screen sharing	*	*	*
F6. Using the chat	+	*	*
F7. Accessing shared content			
F8. Check mic and camera status	*		+
F9. Participants info	*	*	*

Table 3: Inspection evaluation of Google Meet accessibility features

Function	Focus	Shortcut	SR feedback
F1. Joining a Meeting	*		*
F2. Hand Raise	*		*
F3. Turn mic on/off	*	*	*
F4. Turn cam on/off	*	*	*
F5. Screen sharing	*		*
F6. Using the chat	+		+
F7. Accessing shared content			
F8. Check mic and camera status	*		*
F9. Participants info	+		+

Table 4: Inspection evaluation of Teams accessibility features

Function	Focus	Shortcut	SR feedback
F1. Joining a Meeting	+		+
F2. Hand Raise	*		*
F3. Turn mic on/off	*	*	*

F4. Turn cam on/off	*	*	*
F5. Screen sharing	*	*	*
F6. Using the chat	*		*
F7. Accessing shared content	+		+
F8. Check mic and camera status	+		+
F9. Participants info	+		+

The results presented in these tables are now discussed briefly.

F1. Joining a Meeting.
This activity can be performed via keyboard and screen reader with no particular issues for Zoom and Google Meet. In Teams the procedure is quite complicated. The focus cannot be moved onto the button "participate" displayed on the screen, and the SR feedback is not appropriate. The procedure for joining a meeting requires multiple key presses: (1) move the focus via Tab key onto the chat list (requiring multiple Tab key pressures), select via arrow keys the message announcing that "the meeting is started on...", and then pressing the Enter key twice in order to detect the button "participate". Finally, the user can join the meeting by pressing the Enter key one more time. This is clearly not quick and intuitive.

F2. Asking to speak in a meeting.
Many conferencing tools offer a 'raise hand' function to inform the moderator a participant wants to speak. This function is accessible in Zoom and Teams, but not in Google Meet. In fact, in Google Meet 'raise hand' is available only for the G Suite business and for education. So, most users reported that they could not use this function. Only 10 users (36%) were able to use this button to indicate they wanted to speak and seven commented on the need for additional shortcuts. Only Zoom offers the shortcut to Raise or lower the hand. The SR feedback is clear in all the three tools.

F3. Turning the microphone **on and off**
This function is fully accessible for all the three tools tested. The focus can be moved onto to the specific button, or can be used with the assigned shortcut. The SR feedback is satisfactory in Teams and Google Meet, but in Zoom a specific screen reader script is needed in order to announce that the action.

F4. Turning the video camera **on and off**.
This function works similarly to the same function for the microphone. The focus handling and shortcuts work. SR feedback the Zoom requires a specific script to be loaded.

F5. Audio, video, file and screen sharing.
This function is used for video conference presentations. The screen reader or keyboard can be used for the "share" function with either the entire screen or a specific window selected. Sharing the screen or a window and including the audio (when supported) was straightforward, but there were issues with file sharing. In Teams this required the File Tab, which could not be easily detected with a screen reader. In Meet the host but not participants had access to this function and could attach files to be shared in the meeting. Zoom used the Tab key and File sharing could be detected by the screen reader when exploring the chat area.

F6. Accessing shared content.
F5 allows users to share content with other participants, whereas F6 allows users to access content shared by other participants. Unfortunately, screen content shared by other users is shown as an image for all three tools and is therefore inaccessible for screen reader users. SR feedback is just the message "screen sharing by the speaker". However, screen readers are able to detect shared PowerPoint files in Teams. In this case the PowerPoint file content can be detected by screen reader if the presentation has been designed in an accessible way. For instance, each slide has a title, images have an alternative description, and so on. In this case the SR feedback involves reading the slide contents. The shared content can be accessed by using the Tab key to move the focus.

F7. Using the chat.
In this case users need to be able to both read and write/edit messages. Zoom and Teams tools provide better support for using the chat than Google Meet. Only Zoom provides a shortcut to move into the chat area. In Teams the chat area can be reached with the Tab key and then opened using the "Show the chat" button. It is also is accessible in Teams the focus. The user can then use the Tab or Arrow keys to move between reading messages to read and the edit box for writing them. This allows screen reading users can read and write text messages. However, a shortcut to open the chat area would be very useful and has been requested by several users. More problems are encountered in Google Meet. Finding and opening the "Chat" button and locating the edit box are feasible via keyboard, but difficult with a screen reader. The lack of a shortcut to open the chat area means that a large number of steps is required and the user has to listen to the people who are speaking during the meeting while doing this. Reading messages is also task more difficult in Google Meet. The screen reader is able to detect some messages, but the list of messages can only sometimes be detected, as though it is appearing and disappearing. Thus, chat use is very difficult and almost impossible in Meet for screen reader users.
Users can read aloud a message written by another participant in all the tools, when the tool window has the focus. This is very useful, as the message is automatically read by the screen reader. However, users may find it difficult to listen to the message and the speaker at the same time and therefore a

function to scroll through previous messages would be very useful. It is very difficult to use a link in the chat or copy a message in all the tools. This makes the chat considerably less useful as a source of information.

F8. Awareness of microphone and video camera status.
Users often need to know if their microphone and video camera are on or off. Unfortunately, this information cannot be obtained directly by screen reader users and has to be inferred. For instance, the user can turn the microphone or the video camera on/off by using the shortcut and obtain its status from the SR feedback. However, this is not a direct approach and requires the device status to be changed and possibly changed back again to the desired status. Alternatively, the user can move the focus to the on/off button and obtain the current label of this button. A "turn on" label means the device (microphone or video camera) is currently turned off and vice versa. However, this requires interpretation and could distract attention from the speakers. It may also require numerous steps to be performed while the user should be focusing on the speakers and the meeting

F9. Awareness about participants (number, names, who is joining or leaving).
Screen readers users should have access to the same information about the other participants, including their names and number, as non-disabled participants. Zoom, but not Teams and Meet, provides a shortcut to open the participant list. All three tools provide access using the Tab key (Zoom and Teams) or the Arrows key (Meet), but this approach generally requires several steps. The Arrow key can then be used to access information about a specific participant. Zoom provides the most complete and clearest information. Teams provides similar information for each participant, but the order in which it is provided is less logical. The most complete and clear is in Zoom, since all data are presented in a correct order. In Teams, the information available is more or less the same, but in an inappropriate and unclear order. It is more difficult to read the information provided by Meet. Table 5 shows an example of the different ways in which participant information is read by the three tools.

Table 5: Participant information read by the screen reader in the three tools

Tool	Participant information
Zoom	Alex Smith, computer audio unmuted, video on, hand raised Bob White, computer audio muted, video off
Google Meet	Alex Smith Turn off Alex Smith's microphone *button* Bob White Turn off Bob White's microphone
Teams	Alex Smith's profile picture, Alex Smith, on the phone, hand raised, unmuted Bob White's profile picture, Bob White, available, muted

4.1 Survey Results

Twenty-nine totally blind people participated in the study:14 female (48.3%) and 15 males (51.7%). All of them used screen readers and keyboards to access videoconferencing tools.
Their ages ranged from under 20 to 69 years with the distribution shown in Fig. 1. There was a reasonable spread across the different age groups with <20 years: 1 participant: 18-29 years: 5 participants (17.2%); 30-39 years: 7 participants (24.1%); 40-49 years: 9 participants (31%); 50-59: 5 participants (17.2%); 60-69: 2 participants (6.9%); and no participants aged 70+.

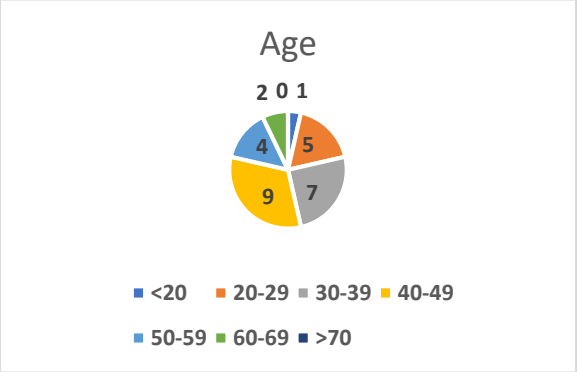

Figure 1: Participant age profile.

Based on their self-reports, participants had varied technical experience and skills and included one novice user, 22 experienced users and six very expert users (Fig. 2). 23 users utilize the PC with the Windows Operating System (OS) and 5 the mac OS.

Figure 2 presents the number of participants able to access different functions in each of the three video conferencing tools platforms. It clearly shows that the better performance of Zoom for accessed functions, followed in general by Meet. However, the fact that only 14 participants had experience of Teams, while almost all (28) participants had used Meet and all 29 participants Zoom.

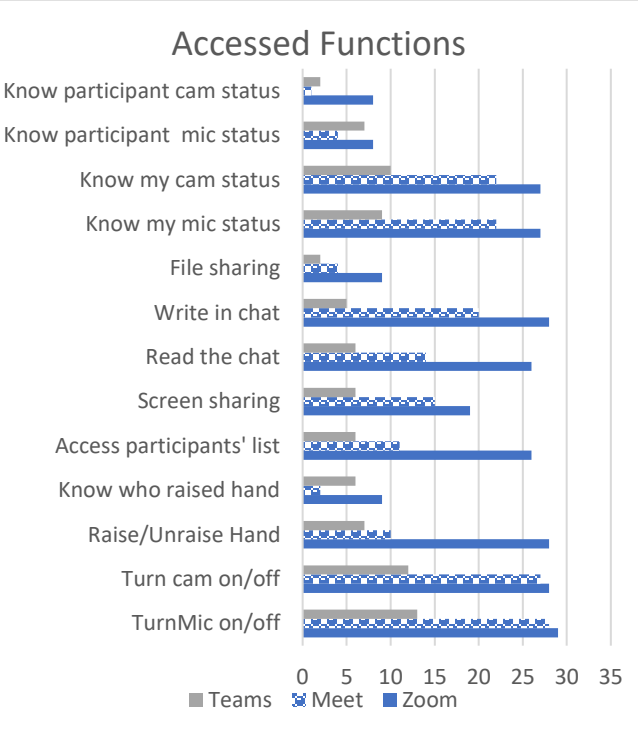

Figure 2: Number of participants able to access different functions in Teams (upper line), Meet (middle pattern line) and Zoom (lower line)

It is also useful to investigate participant use of access keys. Only a minority of participants always used access keys or only used them for some functions in both Zoom (7 in both cases) users and Teams (3 in both cases), whereas a majority of participants (18) used access keys for only some functions in Meet and a small minority (3) for all functions.

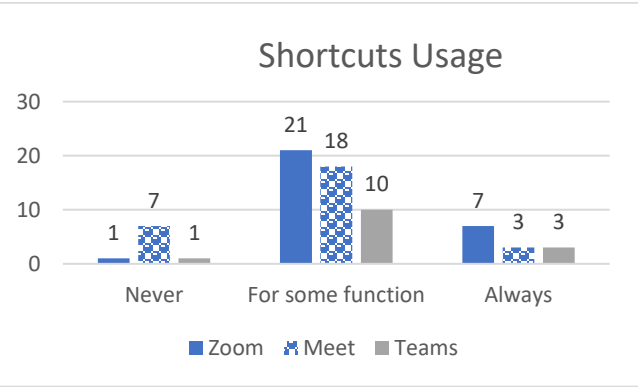

Figure 3: Frequency of use of access key with Zoom (left bar chart), Meet (middle patterned bar) and Teams (right bar)

The results of a 5-item Likert scale evaluation of the difficulties encountered when navigating the tools without an access key, i.e. evaluating structure usability via screen reader indirectly are presented in Figure 4. Zoom was found to have the most navigable and simplest structure.

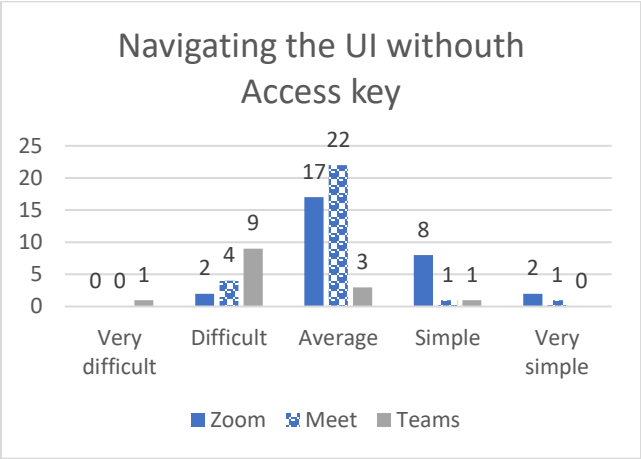

Figure 4: Evaluating navigation vs the structure of the UI, without the use for Access Key with Zoom (left bar cbar), Meet (middle patterned bar) and Teams (right bar)

Figure 5 shows the results of a 5-item Likert scale evaluation of user overall satisfaction with their experiences of tool use.

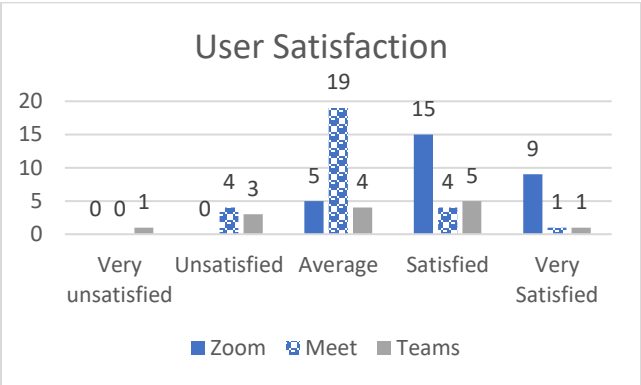

Figure 5: User satisfaction with Zoom (left bar chart), Meet (middle patterned bar) and Teams (right bar)

5 Discussion

The evaluation revealed that the tools provided some means of accessing their main functions via keyboard with screen reader feedback. However, access was frequently not easy due to the lack of shortcuts and other problems. Zoom was found to be the most accessible of the three tools due to the numerous shortcuts available for the main functions.

Table 6 summarizes the level of accessibility supported by the three tools.

Table 6 Summary of accessibility features supported by the tools

Function	Zoom	Google Meet	Teams
F1. Joining a Meeting	*	*	+
F2. Hand Raise	*	+	+
F3. Turn mic on/off	*	*	*
F4. Turn cam on/off	*	*	*
F5. Screen sharing	*	+	*
F6. Using the chat	*	+	*
F7. Accessing shared content			+
F8. Check mic and camera status	*	*	+
F9. Participants info	*	+	+

The study highlighted the fact that none of the three tools was fully accessible via screen reader and keyboard. Zoom was most preferred by the users and the inspection evaluation found that of the three tools it was able to support the greatest number of the basic functions required for participation in an online meeting. However, users reported that they were unable to use several of the functions which inspection evaluation found could be accessed by keyboard and screen reader. Examples include checking of other participants' status (e.g. microphone, video camera or hand raised). This shows the importance of user as well as inspection evaluation and that functions which are theoretically accessible may be difficult to access in practice, particularly during a meeting where users need to concentrate on speakers and what they want to say.

However, users may not have needed or tried to use these features. Comments from some users stated that they were unable to use some functions as they did know how to find them. Inspection evaluation showed that some of the information could be found near the participant's name in the participant list (see the example in Table 5). Order of the information, amount of information and length of each line of information could have affected the readability and usability of the displayed information. In addition, as indicated in the results section, accessing the participant list was itself not always easy. Having to search further to obtain specific information, particularly in the context of a meeting where there were other cognitive demands on the user may well have been too much. Similar comments could be made for the list of chat messages. This shows the importance of information being easily available in practice and not just (complex) mechanisms being provided which theoretically allow access to it.

Some participants found it very difficult to join Teams meetings, as the "participation" button is not clearly visible and several steps are required to get to it. This is not intuitive. Participants considered interaction and navigation with Meet and Teams not to be easy and with Zoom to be moderately easy/difficult. On a five-point Likert scale with 5 indicating greatest ease of use, average values (a) and standard deviations (SD) were Zoom (a=3.34, SD=0.72), Google Meet (A=2.71, SD=0.60), and Teams (A=2.27; SD=0.70). The results of a 5-point Likert scale evaluation with 5 indicating greatest satisfaction, showed that overall participants preferred Zoom (A=4.14, SD=0.69), followed by Teams (A=3.14; SD=1.10) and Meet Google Meet (A=3.07, SD=0.65). The larger standard deviation for Teams indicates greater divergence of participant views that for Zoom and Meet.

Inspection evaluation determined that functions such as checking other participants' microphone and video camera status required several steps and screen reader output. Doing this while a meeting is in progress and participants are trying to listen to other speakers or think about what they are going to say may add significantly to the cognitive load. Thus, function access should be simplified and require few steps. Nine participants commented on this type of issues, with seven of them wanting additional access key to facilitate navigation of the user interface and one requesting shortcut standardization.

The study revealed the need for improvements to chat access, though some users were able to read chat messages as soon as they were posted. They wanted messages to be easier to read and a reduction in the information provided for each posted message. Seven participants experienced problems with links in the chat, five with clicking on them and two with copying the message text. This is therefore another area where improvement is required.

Several important functions, such as accessing shared content such as slides could not be carried out with keyboard and screen readers. Several participants noted this problem, with some of them saying they were puzzled by this, as the source documents or presentations were accessible.

Sharing files with other participants was found to be easier than accessing other participants' files and some participants stated they were able to share files during a meeting. This is possible, but complicated in Teams and Zoom. In Google Meet participants can find the attachment to the invite saved in the calendar, but this needs to be prepared by the host and can be complicated with a screen reader.

Shortcuts are particularly useful in supporting interaction with the conferencing tools and can avoid having to try and listen to and make sense of speakers and the screen reader output at the

same time (Guo et al., 2016). Thus, easily memorable shortcuts should be provided for all the main functions. Only a minority of participants found it simple (a Likert scale value of 4+) to use the tools without shortcuts 34.5% (10 of 29) for Zoom, 7.1% (2 out 28) for Meet and 7.1% (1 of 14) for Teams. Customisation options for the user interface could be helpful in simplifying it and better adapting it to the needs of screen reader users.

Finally, concerned the perceived user satisfaction, 24 of 29 participants (83%) expressed positive feedback (4+ on the Likert scale) for Zoom, and only 5 out 28 (18%) and 5 out 14 (36%) for Meet and Teams respectively.

The study indicated that, while it is possible to use many of the available functions, particularly on Zoom, user experiences could be considerably improved and many functions made much easier to use. This leads to the following preliminary recommendations to the designers of video conferencing tools which will be developed further and added to in subsequent work.

Keyboard interaction should be simplified and made faster through the provision of easily memorable shortcuts for all the (main) tool functions.

Chat access should be made easier by providing clear information about message order and easy keyboard access.

Participant information should be easy to find and read. Thos should include keyboard shortcut access to the participant list, easy scrolling down the information, a standardised order of the information for each participant with the most used information first

Toolbars and separate windows can be used to arrange the user interface so that the focus can be better handled via keyboard and screen reader. Improved focus handling should be taken in to account during the tool design and development.

6 Conclusions

In this work we have presented the results of investigation evaluation and a survey with responses from 29 screen reader users on accessibility and usability of the desktop versions of three popular conferencing tools, Zoom, Google Meet and MS Teams. The aim was to analyse accessibility and usability of the main functions via screen reader and keyboard.

The results indicated that the very basic functions and tasks can be used via screen reader and keyboard, but that participants experienced a number of issues and that ease of use was often poor. Particular difficulties related to the need to try to listen to and understand speakers and screen reader output at the same time. This and the need for faster and easer navigation led to a demand for more shortcuts to facilitate access to functions by reducing the steps involved and the need for screen reader output. A number of participants frequently reported tasks such as turning the microphone and video camera on/off to be inaccessible, though the investigation evaluation determined mechanisms by which they could be carried out. This was due to a combination of requiring a large number of key presses and difficulties in listening to the meeting and the screen reader output at the same time.

The inspection evaluation investigated the procedures involved confirmed that multiple key presses were generally required to access functions and the focus and explore the user interface. The evaluation also revealed that tasks which in theory could be carried out using keys and screen reader, in practice could be too complex and time consuming for users in practice, leading to reports that these functions were inaccessible. A specific example is joining a Teams meeting where it was not easy to find the 'participation' button.

Overall, Zoom was preferred by 83% of survey participants, followed by Teams with 36% and Meet with only 18%. The inspection analysis confirmed that that Zoom is the most accessible of the three tools via keyboard and screen reader.

The authors have presented several preliminary recommendations which will be further developed and added to. They include the need for keyboard shortcuts for all the main functions, easier access to participant information and clearer organisation of the chat.

The authors have planned a programme of further work. This will include a more detailed investigation of specific features as well as the mobile versions of the three tools considered here. This will lead to further guidelines based on this proposed here. In addition, the authors intend to carry out a larger scale survey involving a wider variety of disabled people and additional video conferencing tools.

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