Making Everyday Objects More Inclusive: A Case Study via Remote Participatory Design

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Abstract. Interacting with everyday objects remains a challenge for blind and visually impaired people who rely on assistive technology. This study investigates how to exploit Information and Communication Technology (ICT) to make everyday objects more accessible for people with visual disabilities, and help create a more inclusive society. A participatory design process including five blind and two visually impaired users was carried out in Italy, exploiting video conferencing tools with the aim of increasing the usability of everyday objects, based on visual interfaces, usually poorly accessible to sightless people. As a case study, a well-known traditional paper-based calendar was selected, since it is a very popular object used at home, at work and in social life. Although digital calendars are very popular nowadays, a tangible paper-based calendar may be more suitable or preferred by users, in specific contexts. Due to people's various needs and preferences, a set of suggestions emerged from this valuable experisence in co-design sessions with technical teams and end users, which can be applied in other contexts where additional information is required.

Keywords: Visually-impaired users · everyday objects · Tangible interfaces · QR-code · accessibility · inclusive society

1 Introduction

As digital solutions pervade our life, new access modes are needed to make tools, artefacts and apps accessible to all, regardless of disability. One of the most popular objects is the calendar, paper-based as well as digital format, including date pickers, interactive or personal calendars [1]. Many studies indicate that the inclusion of people with disabilities is a key factor in those individuals' psychological and social wellbeing [2] as well as a powerful learning motivation factor [3]. Exploiting technology to make everyday objects more accessible is a valuable step toward individual autonomy, in a lifelong pathway of inclusion.

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This study was carried out jointly with the Institute for Research, Training and Rehabilitation (I.Ri.Fo.R.), which as a branch of the Italian Union of the Blind and Visually Impaired seeks solutions to improving the independence of visually impaired people in everyday life. The willingness of the Campi publishing house to make its calendar accessible provided an opportunity to investigate this study's solutions to designing a paper-based calendar for everyone, including people with visual impairments. In particular, the aim of this study was to enable a multimodal and multimedia use of the paper calendar so that it is also usable through the assistive technologies used by people with visual disabilities. Co-design with blind and visually impaired users was applied in our case study.

The participatory design process proved to be fundamental for increasing accessibility and usability of any physical or digital object or artefacts, including applications. In this study, a participatory design approach was applied to making a paper-based calendar more inclusive by exploiting technology to enrich it with additional digital accessible contents. From the beginning this approach involved visually impaired and blind people, who have first-hand experience with the problems they face every day and can propose solutions as co-designers on a technical team.

The most famous Italian lunar calendar is the Barbanera Calendar, in print ever since 1762 [4]. It has always been widely used by families since it offers information about lunar phases linked to the stages of raising crops: sowing, cultivating, harvesting, etc. This is why we decided to select this calendar as a case study, to render it more accessible and inclusive.

The final solution is based on the combined use of the following technologies:

- traditional Braille code to mark the day
- QR (quick response) code to enrich the information with audio or textual descriptions
- Audio (mp3) content that can be triggered via a QR code
- Digital web-based content and pages to choose a specific day (web page with the list of days)

Two main questions emerged in our case study:

- How many QR codes can be placed on a page and at what distance?
- How can a blind user identify the position of a QR code to be detected via smartphone?

In the following we describe in detail the design phases of our work and answer these two questions. The paper is organized into seven sections. Section 2 introduces the Related Work and Sect. 3 the methodology that drives the project. Section 4 describes the participatory design process of the Accessible Calendar. Section 5 discusses the results and Sect. 6 suggests a set of guiding principles for designers. Conclusions end the paper.

2 Related Work

Nowadays ICT technologies and the Internet network enable the automatic association of additional content to (everyday) objects. Thanks to the ability to identify univocally an object in the Internet network, it is possible to augment the object by showing or announcing additional information and content. Radio Frequency Identification (RFID)

tags and readers [5], Near-field communication (NFC) labels with smartphones (reader) [6], and more recently beacons and bi-dimensional QR codes with mobile applications are examples of enabling technologies that can trigger dynamic (web) content uploading [7, 8].

Previous research focused on making Web calendars more accessible for screen reader users. Calendar widgets can pose accessibility problems. Although accessible, the calendar is poorly usable via screen reader since arrow keys enable sequential exploring of dates (one by one), the announced content can be unclear ("M" instead of "Monday"), and table shortcuts might not work [9].

Other authors have investigated the problem of audio access to calendars by designing a non-visual interface for selecting dates on web-based forms in order to provide audio access to date selection while automating the formatting of dates. The proposed calendar date entry system reduced errors in date format when a user has to insert a date [10].

WebbIE is an example of a calendar app specifically designed for blind users [11]. It is a desktop application with a simple user interface with just a few buttons and menus that can easily be navigated by keyboard and screen reader. However, it is very simple and does not deliver important functions such as location, additional information, and confirmations of deleted events and was not recently updated. More recent apps are designed to be used on mobile devices. An accessible and usable interface for a dynamic web-based calendar was proposed by [12].

A collection of common mobile Apps (such as phone, contacts, messages, calendars, notes) accessible for visually impaired users has been organized in an accessible mobile portal designed for easy interaction and customization for low vision users (icon size, colors, screen contrast, voice speed) [13].

Recently companies such as Google, Microsoft, and Apple provide users with their calendars integrated into the OS. For instance, the sophisticated Google Calendar provides APIs to incorporate its digital calendar functions in apps. The Calendar API lets developers integrate their apps with Google Calendar, created for engaging users (https://developers.google.com/calendar/api). Thus developers can save resources, by reusing components (API libraries) without the burden of development and maintenance over time. These components have to provide support for use with a screen reader to make interaction comfortable and satisfying for blind users.

Analogously, mobile phones and tablets (Android, iOS) integrate their own calendars. Date pickers and calendar applications are available today on touch-screen devices. Users can interact with gestures and finger touch. This modality was a revolution for blind users enabling easy interaction with mobile phones [14].

With the rapid evolution of technology, people with special needs such as blind and visually impaired (BVI) people can especially benefit from using voice assistants such as Siri or Alexa. They are very useful for BVI people thanks to the vocal interaction and the audio information exploited in everyday-life tasks. By conducting an online survey with 145 participants, authors discovered that common voice assistants are used by most BVI people and are considered helpful; especially in everyday life practical tasks like checking for weather, setting an alarm clock, checking calendar entries and taking notes are particularly useful and frequently used [15].

However, to the best of the authors' knowledge, a hybrid modality of the tangible and digital calendar has not yet been described. Moreover, the experience of co-design with BVI people, exploiting video conferencing tools that may pose accessibility and usability problems for blind users [16] has been tackled in the project by collecting valuable user feedback and suggestions.

3 Method

Participatory Design (PD) exploits different tools and strategies to make users become designers in order to improve the usability of designed artefacts. "We can make user experience the source of inspiration and ideation for design. And by making user experience the source of inspiration, we are better able to design for experiencing" [17]. A change is required in this approach with the awareness of the value of designing with users instead of designing for users (a method prone to subjective interpretations during the design process, negatively impacting the artefact's usability). To this aim, appropriate tools to express the user's full design potential must be provided. As participants in the PD are from different and not homogenous domains, it might be necessary to establish a common language to be shared between all design team participants to facilitate communication and comprehension.

Participatory design implies investigating, reflecting, understanding, modeling, developing, and stimulating and sustaining mutual learning processes during the design process. The interplay between competence, skills, experiences, emotions enhance mutual learning through a synergic cooperative process [18].

A participatory design approach has been applied since the beginning of the study. The design of an accessible calendar was carried out in collaboration with the Barbanera publishing house, which was interested in making their paper-based calendar accessible also to people with vision impairments, and with the Italian Association for the Blind, which participated in the design of the proposed solution. End users who have experienced interaction problems can provide crucial cues and guidance to create products simple to use, easy to understand and able to deliver a satisfying experience [18].

The participatory design approach with incremental steps led to the multimodal and multimedia solutions described in the following. Traditional and digital technologies have been exploited to develop the solution proposed in this study, as described in the next sections.

The design team was composed of a group of people with various skills, experiences and abilities: a designer from the Barbanera calendar Publishing House, two technicians, and one expert in graphic design (sighted). The blind participants were recruited by the Italian Association for the Blind. Seven users with visual impairments (five men and two women aged 32 to 67 years) took part; five were totally blind and two were visually impaired. Users were comfortable with technology and the use of computers and smartphones. In addition, a researcher expert in accessibility – the blind author of this work -- was included in the team, thus resulting in a total of eight blind people involved from the start of the design process. Although not statistically significant due to the low cardinality of this sample, in our opinion they could represent the experienced problems, feelings and the ideas of the visually impaired since the eight blind team

participants ranged from very expert to novice, including both young and older people, and comprising three females and five males.

Once the paper-based initial prototype was ready, a preliminary printing of a limited edition of the calendar was carried out by the editor, as a pilot test. The publishing house then sent the first calendar prototype to all participants to perform a preliminary evaluation and share feedback and suggestions. User feedback was collected and analyzed to prepare a new version of the calendar prototype. Finally, a focus group was held in attendance at the association's headquarters with all participants for testing the new version of the prototype.

4 Participatory Design: Case of the Barbanera Calendar

In this section, we describe the design phases and the development of the calendar in an accessible version following the indications of the visually impaired members of the team.

4.1 Barbanera Calendar

Barbanera has been a famous Italian almanac and calendar since 1762. In its paper format, it offers valuable daily advice according to the seasons and the Moon phases. The Barbanera tradition is a UNESCO 'Memory of the World' [4].

The calendar is presented in a paper format with an eye-catching and rich graphic look for the reader. In addition to the cover, each page of the month shows: (1) the days' dates with an indication of the saint of the day (on the front of the page), and (2) advice regarding the harvest, how to sow, useful tips for the home, horoscope, etc. (on both the front and the back of the page). All this information is written on the calendar itself. The calendar thus not only provides an overview of the days of the month, but also offers useful information for all the members of a family.

We chose this type of calendar not only because of its popularity in Italy, but because it offers a lot of information, which can therefore be made more accessible in digital format.

4.2 Designing the First Prototype

The two-step participatory design carried out by the team enabled the development of an accessible technology-enhanced version of the Barbanera paper-based Calendar. As previously mentioned, the team comprised two researchers (one totally blind), the Barbanera technical team (sighted people), and seven visually impaired people with different technical skills.

Due to the Covid-19 pandemic, the team worked remotely in a collaborative way exploiting video conferencing tools. Specifically, Zoom was used since it was preferred by visually impaired participants. In the first meeting, with the other members of the team the participants analyzed the main features and the graphic appearance of the calendar in paper form. As a result, the main issues experienced by the visually impaired in accessing paper-based calendars as well as the user requirements were collected during the focus

group meeting. A second meeting with the participants allowed the team to develop possible strategies to apply in order to work out a format enriched with digital content, to make it accessible also to people with visual impairments. Accessibility principles drove the design of the first draft of the prototype.

Usually, co-design sessions are performed in presence by using visual based tools to favour creativity and collaboration. In this study, the collaboration and cooperation relied first and foremost on voice interaction based on in-depth descriptions.

In the first remote meeting, the visually impaired participants shared information about the main issues faced when carrying out everyday activities, as well as the assistive technologies usually used to overcome them. The members of the publishing house shared information about the graphical rendering of the calendar. The accessibility expert researcher (who is a computer scientist) introduced accessibility principles and current technology solutions to the group. Participants with visual impairments expressed interest in a solution that on one hand included tactile elements that may be more familiar to the blind, and on the other hand exploited the most popular technologies in the blind community for accessing digital content.

The first prototype of the accessible Barbanera calendar was conceived and took shape over several meetings. In the design, four parts of the paper-based calendar content were digitally expanded: a) Cover information b) Contents of the month c) The phases of the moon and d) The information of the day. This suggests exploiting ICT to augment the information associated with the object.

The QR code was acknowledged by all team members to be a suitable tool for enriching the calendar information with digital content. When scanned via a mobile app, the QR code triggers the opening of an URL in the browser, and the page can contain text and/or multimedia objects. Some accessibility aspects of using QR codes and the applications needed to be discussed with the visually-impaired participants:

- *QR code Detection.* Visually, the QR code is easily recognizable. For a blind person, it is not easy (I) to know whether QR codes are present and if so (II) where they are located in order to be framed by the camera.
- *Number and positioning of QR codes.* It was necessary to figure out how many codes to apply and where to place them.
- *Marking of days.* To facilitate the consultation of the paper calendar by a blind person, it was necessary to understand how to mark the days so that the blind person can identify the days and thus the information associated with them.

The first prototype included the use of the QR codes to tag the following elements: day information (for all days), cultivation descriptions, horoscope and partners' websites. For the day information, specific written or audio content about the day was added. The cover page and an example of a month (January) are shown in Fig. 1 (a) and (b).

In the first page prototype, each day was marked with a QR code linked to the day's description loaded on the publishing house's website, for a total of 31 QR codes for the month of January. Two links were placed at the bottom of the page for the horoscope and cultivation descriptions.

When the user scans a QR code with a smartphone camera via an app, the corresponding URL can be triggered. However, scanning the QR code can be a difficult task for a screen reader user. QRBlind is an app specifically designed to handle QR codes

Fig. 1. Accessible calendar first prototype – a) Cover page b) Month of January

by visually impaired users, available in the Apple Store. It is fully accessible via screen reader and provides five push buttons that enable the functions: Go to the Web address, Add or Modify a QR Code, Play Audio, Create a new Label, Share QR Code. The app enables a blind person to create a QR code in a simple way. This is very important for their autonomy since it enables the creation of personalized labels that can be scanned via QR code for reproducing stored audio descriptions. This app was used to test the page prototype. Figure 2 shows the blind user scanning the Barbanera calendar month page via QRBlind. Analogous apps are available for the android platform such as VIP Code Reader - Blind scanner.

Fig. 2. QR code scanning with QRBlind

4.3 The Pilot Test and Second Design Iteration

In the second Participatory Design iteration, issues highlighted by the pilot test were addressed by the multidisciplinary team, in order to make the calendar more accessible and usable.

The pilot test was performed over a 3-week period to ensure that any participants received the calendar prototype via postal mail. Three tasks were assigned to the user via email and WhatsApp group:

1) explore the cover page and read the info about the Barbanera. This task evaluates the use of the QR code on the left at the top of the cover page
2) explore the page for January and read the information on day 6. This task evaluates the usability of the QR codes associated with each day (i.e., QR code detectability and distance)
3) Count the number of QR codes on the cover page. QR codes on the cover have been manually embossed with one point in relief in order to make the tactile detection of the QR code easier.

The test was performed autonomously by each participant, while the feedback was shared through written comments or audio messages via WhatsApp. Feedback was read (or listened to) during the next meeting and then commented on by all the team participants. Researchers annotated those comments for better analysis.

Problems and technical solutions to be addressed were mostly discussed during the meetings until a consensus was reached among the team. The most significant issues that emerged were related to:

- QR code activation. Having many QR codes too close together on the page may cause some difficulties since the camera may trigger the first detected QR code as soon as the user moves the camera focus over the day dates. To resolve this issue, a digital solution was implemented: using just one QR Code to refer to a single web page including all the days. Thus, the user can select the desired date to listen to the description of the day. Thus, in this way the solution includes a digital list of the days that can be navigated via smartphone/computer and assistive technology. When the day is selected on the page, the user can listen to/read the associated information (audio files in mp3 format). The days could be arranged in various ways, such as a list (solution applied to the prototype), a link or a button for each day, or alternatively a combo-box or a dropdown menu.
- Limiting the use of Braille labels. Since Braille requires coding each character with a sequence of dots in relief, the Braille translation of textual documents may need too much space to fit on the calendar page. Thus only a few labels were reproduced in the paper-based calendar, while additional information was delivered throughout the audio/digital channel.
- Color, contrast and fonts. Difficulties related to the rendering features were experienced by the low-vision users in reading the days and the related writings. Fortunately, after having removed the QR codes from each day (using just one), some space was saved and so the graphical appearance was rearranged by changing some layout features (font type and size).

4.4 Final Prototype

In the Barbanera calendar all suggestions were taken into consideration except the shapes in relief which had been suggested by users for the lunar phases, due to the difficulty of reproducing it on paper. More specifically:

- *Braille labels.* Each day was marked in Braille code. For this purpose, traditional Braille printing was used in order to keep the page unchanged. In fact, the Braille dots cause tiny holes on the opposite side of the sheet. For this reason, the technique applied by the publishing house consisted in reproducing the Braille character by composing the same dot by dot with an embossing material. In this way, the back of the page was been altered. This made it possible to write text on the back of the month page to make the content available to sighted people (i.e., maintaining the format of the original calendar).
- *QR code detection.* One dot on the left side of the QR code was introduced to make it easily detectable by touch.
- *Number of QR codes.* The cover page of the new version of the accessible calendar is shown in Fig. 3. Four QR codes were placed at the bottom of the cover page. The QR code on the left refers to the Barbanera website and particularly by reproducing the current day's info (see Fig. 4). The 2022 QR code links to the event page (see Fig. 4). Figure 5 shows the month page. Due to problems detecting the QR codes when they are too close together, it was decided to insert only one QR code referring to the whole list of days. This was placed on the top left. Scanning this QR code, the user accesses the list of all audio content related to all days of that month (Fig. 6). In addition, to quickly obtain info related to the current day, a specific QR code was added to the top right-hand side linking to the day info (Fig. 6). It is important to note that the QR code on the top right of the page links to the info about today's day (regardless of the month page that the user is exploring).

Fig. 3. Barbanera calendar – Cover page 2022

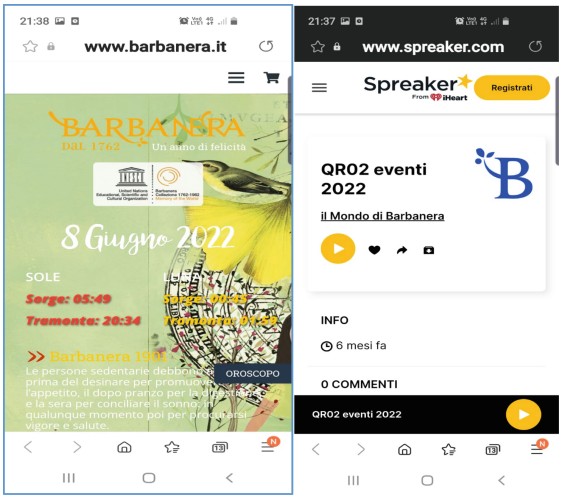

Fig. 4. Scanning the cover page: a) Day Info (top left QR code) b) Event 2022 page (middle right QR code)

Fig. 5. Barbanera calendar: Month page

As in the first prototype, the two QR codes placed at the bottom of the page refer to the horoscope and agricultural information related to phases of the moon (Fig. 5).

As previously mentioned, the QR code in the top left corner brings the users to a web page navigable by flick left & right screen gestures, enabling listening and the navigation of all the month's audio files (one for each day) (Fig. 6a) Please note that with respect to the possible solutions, the most usable was selected since moving up and down with one's finger is the easiest and best-known option for blind people. The QR code in the top right corner activates the day's textual content (Fig. 6b).

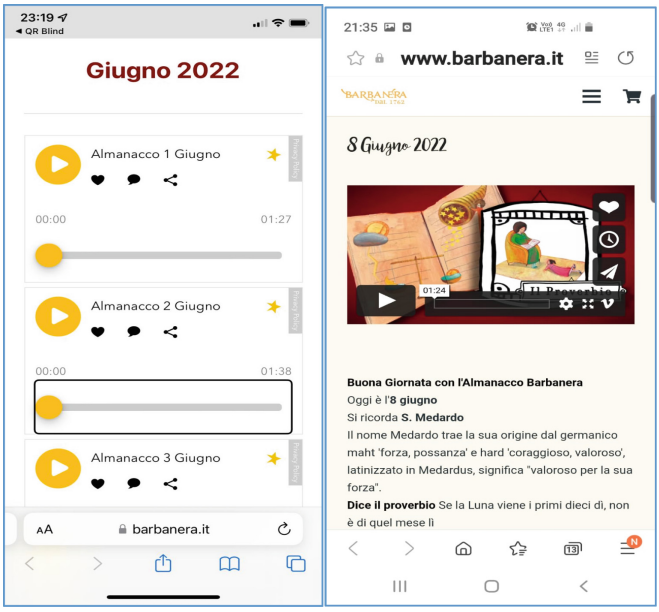

Fig. 6. Scanning the month page: a) Audio Files List (QR code top left) b) Info of the day (QR code top right)

Considering the final version of the calendar, the feedback received from (sighted) readers was very positive. Five thousand copies were distributed for Christmas 2021 (to associates, politicians, etc.). Considering both calendars and almanacs, about 3,000,000 in all -- of which more than 2,000,000 calendars have been sold in 2022 -- were distributed throughout the commercial network (both online and in newsstands). The accessible format has been confirmed for the 2023 version (as shown in Fig. 7).

Fig. 7. Barbanera calendar – Cover page 2023

5 Discussion

The experience of codesigning the augmented calendar with sightless end users enabled us to test the video conferencing tools as a means for remote collaboration. The results are encouraging. Blind people were very active and interested in exploiting technology.

We learned that people with visual impairments reacted positively to this collaboration via video conferencing tools. Users stated that these two years of pandemic allowed them to learn about the new remote communication tools and that they can now be used for many purposes. They also stated that in these two years, the opportunities for remote meetings have increased thanks to the new tools, allowing more participation and more activities.

Herein we focus on visually impaired users but the augmented content (which can be perceived through different senses) can benefit any person, including children, elderly, students and so on.

This case study of making the paper calendar more inclusive for all is a clear demonstration of how simple existing technologies can be combined to make content more accessible in a variety of ways and with a variety of devices. Augmented content can thus be useful assistive technologies for many categories of users. This approach could be better investigated in the design of other everyday objects to disseminate a methodology that can contribute to a more inclusive society. In the next section, some early design suggestions are proposed, to be further investigated in similar situations.

6 Design Suggestions

After analyzing the feedback regarding interaction with the calendar prototypes by blind and visually impaired, the multidisciplinary team proposed a set of suggestions to design a more inclusive format. These suggestions are easily generalized for all disabilities, not only the visual.

1. **Exploit tactile sensing to deliver information**. Braille letters and relief shapes can deliver information since they are easily recognizable by touch. Two features have been suggested to be easily and rapidly detectable by touch:
   a. *Tactile cues.* The idea is to exploit Braille dots to localize QR codes. The tactile dots enable the user to correctly and rapidly identify the QR codes. For example, the same can be placed in the upper left corner of each QR code.
   b. *Tangible icons.* If icons relating to the lunar phase are inserted (full moon, first quarter, etc.), in order to make moon phases tactilely perceivable, the outline of the moon icon can be marked in relief. In the case of a full moon, the same could be highlighted with a full circle, while in the case of a new moon, the circle could be empty.
2. **Maintain consistency between tactile cues**. It is important that for each QR code, the tactile dot is always inserted in the same position in order to maintain consistency and allow the blind person to know exactly where the QR code is located.
3. **Optimize QR Code Positioning**. Having QR codes too close on the page may cause difficulties since the camera triggers the description of the first detected code as soon as the user moves the camera focus over the dates of the days. A blind person might not

be very precise when focusing on an item. To resolve this issue, a digital solution can be implemented: only one QR Code can be used to refer to a single digital page showing a list of the days, which can be selected by the user via a smartphone/computer and an assistive technology. When the day is selected on the page, the user can listen to/read the associated information (audio files in mp3 format). Various technical design solutions can be applied: e.g., using a link or a button corresponding to each day, or alternatively a combo-box or a dropdown menu where the user can edit (or select from the list) the desired day. For the day's info, specific written or audio content can be assigned and thus triggered.

4. **Optimize calendar graphic format for readability**.
   a. The standard format with a single list of days placed one under the other would make much more space available to write the information that is more visible even for visually impaired people. To keep information readable, the more compact grid format requires an app to enrich content and information not only for the blind but also for the visually impaired.
   b. Whenever possible, avoid paper that is too glossy. Better mark the number of days with a more full-bodied font (https://www.letturagevolata.it/). Concerning fonts, colors, and contrast for facilitating reading for visually impaired people see the World Wide Web (W3C) resources [19].

In conclusion, making everyday objects more accessible to blind and visually impaired people is crucial to making a more inclusive society.

7 Conclusions

In this paper we describe a remote participatory design process which drove the design of an inclusive paper calendar exploiting QR codes, Braille labels, audio descriptions and web pages.

The proposed approach can be replicated in all contexts including paper-based objects such as a diary, map or personal organizer. Furthermore, this approach can be useful for addressing the needs of other disabilities such as neurodevelopmental or hearing, augmenting objects with pictures or AAC (Augmentative and alternative communication) or videos.

From this study, we can conclude that participatory design using video conferencing tools deserves further investigation. Future work can assess this remote modality vs traditional participatory design in presence for visually-impaired people.

Moreover, it would be important to explore the accessibility of calendar and schedule apps such as Google calendar and Doodle, which by now have become essential tools for supporting and organizing daily work.

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References

1. Huang, D., Tory, M., Bartram, L.: A field study of on-calendar visualizations. arXiv preprint arXiv:1706.01123 (2017)
2. Eisenman, L.T., Freedman, B., Kofke, M.: Focus on friendship: relationships, inclusion, and social well-being. In: Handbook of Positive Psychology in Intellectual and Developmental Disabilities, pp. 127–144. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-59066-0
3. Dickinson, H., Smith, C., Yates, S., Tani, M.: The importance of social supports in education: survey findings from students with disability and their families during COVID-19. Disabil. Soc. 1–23 (2021). https://doi.org/10.1080/09687599.2021.1994371
4. Barbanera calendar. http://www.barbanera.it/
5. Sedighi, P., Norouzi, M.H., Delrobaei, M.: An RFID-Based assistive glove to help the visually impaired. IEEE Trans. Instrum. Meas. **70**, 1–9 (2021). https://doi.org/10.1109/TIM.2021.3069834
6. Lim, K.Y., Ho, Y.L.: NFC label tagging smartphone application for the blind and visually impaired in IoT. In: Kim, H., Kim, K.J., Park, S. (eds.) Information Science and Applications. LNEE, vol. 739, pp. 305–315. Springer, Singapore (2021). https://doi.org/10.1007/978-981-33-6385-4_29
7. Dabke, R.B., Harrell, M., Melaku, S., Ray, L., Turner, H.: QR code labels and audio commentaries for commonly used chemistry laboratory apparatus: an assisted learning experience for visually impaired students. J. Chem. Educ. **98**(10), 3395–3399 (2021). https://doi.org/10.1021/acs.jchemed.1c00058
8. Senjam, S.S., Souvik, M., Covadonga, B.: Smartphones-based assistive technology: accessibility features and apps for people with visual impairment, and its usage, challenges, and usability testing. Clin. Optom. **13**, 311 (2021). https://doi.org/10.2147/OPTO.S336361
9. Ashok, V., Puzis, Y., Borodin, Y., Ramakrishnan, I.V.: Web screen reading automation assistance using semantic abstraction. In: Proceedings of the 22nd International Conference on Intelligent User Interfaces, pp. 407–418 (2017). https://doi.org/10.1145/3025171.3025229
10. Brown, A., Jay, C., Harper, S.: Audio access to calendars. In: Proceedings of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A), pp. 1–10 (2010). https://doi.org/10.1145/1805986.1806028
11. King, A.: WebbIE Calendar. https://www.webbie.org.uk/calendar/
12. Wentz, B., Lazar, J.: Usable web-based calendaring for blind users. In: Proceedings of HCI 2011 the 25th BCS Conference on Human Computer Interaction, vol. 25, pp. 99–103 (2011). https://doi.org/10.14236/ewic/HCI2011.33
13. Sierra, J.S., Togores, J.: Designing mobile apps for visually impaired and blind users. In: The Fifth International Conference on Advances in Computer-Human Interactions, pp. 47–52 (2012)
14. Leporini, B., Buzzi, M.C., Buzzi, M.: Interacting with mobile devices via VoiceOver: usability and accessibility issues. In: Proceedings of the 24th Australian Computer-Human Interaction Conference, pp. 339–348 (2012). https://doi.org/10.1145/2414536.2414591
15. Mehta, Y., Joshi, A., Joshi, M., Jadhav, C.: Accessibility of date picker for touchscreens. In: Proceedings of the 8th Indian Conference on Human Computer Interaction, pp. 64–69 (2016). https://doi.org/10.1145/3014362.3014368
16. Leporini, B., Buzzi, M., Hersh, M.: Distance meetings during the covid-19 pandemic: are video conferencing tools accessible for blind people?. In: Proceedings of the 18th International Web for All Conference, pp. 1–10 (2021). https://doi.org/10.1145/3014362.3014368
17. Sanders, E.B.N.: From user-centered to participatory design approaches. In: Design and the Social Sciences, pp. 18–25. CRC Press (2002)

18. Robertson, T., Simonsen, J.: Challenges and opportunities in contemporary participatory design. Des. Issues **28**(3), 3–9 (2012). https://doi.org/10.1162/DESI_a_00157
19. W3C: Accessibility Requirements for People with Low Vision. W3C First Public Working Draft 17 March 2016 (2016). https://www.w3.org/TR/low-vision-needs/