Online-Journals.org

iJOE International Journal of Online and Biomedical Engineering

iJOE | eISSN: 2626-8493 | Vol. 20 No. 13 (2024) | OPEN ACCESS

https://doi.org/10.3991/ijoe.v20i13.50025

PAPER

Crafting Personalised Web Interfaces: Enhancing Accessibility for Persons with Disabilities

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ABSTRACT

This paper investigates the creation of multimodal web interfaces to foster inclusive services, aiming to empower individuals with disabilities. This paper details the development of SEU (Services to Empower yoU), an online platform designed to improve access to offline services for persons with disabilities through personalised multimodal web interfaces. Developed using a participatory design approach, SEU involved collaboration with Human-Computer Interaction experts, occupational therapists, accessibility experts, and persons with disabilities. The platform supports multiple user needs across cognitive, visual, motor, and hearing impairments. SEU was evaluated in a two-phase usability study, which included expert assessment and testing by persons with disabilities, supplemented with interviews, observations, and questionnaires. Feedback highlighted SEU's effective design and usability, emphasising its utility in enhancing service accessibility. The study indicates that both experts and persons with disabilities consider the platform an added value. Although the platform was well-received, suggestions for better cognitive support and the addition of a mobile application were noted, acknowledging the regular smartphone usage among the target users.

KEYWORDS

digital accessibility, web platform, persons with disabilities, user study, inclusive design, HCI

1 INTRODUCTION AND BACKGROUND

This paper presents exploratory research on the design of personalised web interfaces to empower persons with disabilities (PwD). The research includes the development of the online platform "Services to Empower yoU" (SEU) to support the acquisition of offline services by PwD, providing accessible personalised user interfaces (UI) according to the types of users. The United Nations Convention on the Rights of Persons with Disabilities (CRPD), ratified by 177 states in March 2019, acknowledges the significant role of information and communication technologies in empowering and enabling PwD to enjoy their human rights and

Macedo, P., Madeira, R.N., Miranda, P., Santos, P.A. (2024). Crafting Personalised Web Interfaces: Enhancing Accessibility for Persons with Disabilities. *International Journal of Online and Biomedical Engineering (iJOE)*, 20(13), pp. 84–102. https://doi.org/10.3991/ijoe.v20i13.50025

Article submitted 2024-05-08. Revision uploaded 2024-07-15. Final acceptance 2024-07-18.

fundamental freedoms fully [1]. The SEU concept aims to address key aspects such as (1) Enhancing Autonomy through Accessibility, (2) Mitigating Social Isolation, and (3) Promoting Empowerment and Self-Efficacy. Different studies have established a positive correlation between perceived autonomy, self-efficacy, and the mental well-being of individuals with disabilities [2] [3]. SEU started under a makeathon event of Tikkun Olam Makers (TOM)[1], where a societal challenge was launched regarding the needs of PwD, who would acquire inclusive offline services by taking advantage of the ubiquity of the web. There was a need to develop an inclusive but also secure digital solution, and the following main research question was posed: "What are the key considerations for designing web interfaces tailored to address the unique requirements of users with distinct impairments?"

Empowering individuals with disabilities through accessible technologies not only increases their autonomy, but also enhances their sense of control and confidence in navigating daily life. By providing inclusive digital platforms, we can facilitate independent access to information, services, and opportunities, thereby positively impacting the mental well-being of individuals. In addition to autonomy, mitigating social isolation plays a vital role in the mental wellbeing of individuals with disabilities. Research studies have consistently shown that fostering a sense of belonging and reducing feelings of isolation improve significantly the mental well-being of individuals with disabilities [4] [5].

Accessible web platforms and online communities provide avenues for social connection, allowing individuals with disabilities to interact, share experiences, and receive support from others facing similar challenges. These virtual connections contribute to reducing social isolation and promoting mental wellbeing. Furthermore, promoting empowerment and self-efficacy are crucial factors in enhancing the mental wellbeing of individuals with disabilities. By offering personalised interfaces, assistive technologies, and resources tailored to individual needs, accessible web platforms empower individuals with disabilities to overcome obstacles and pursue their goals [2]. This empowerment fosters a positive mindset, increases self-confidence, and reduces the risk of depressive symptoms.

As the web is a fundamental tool in the daily life of most citizens, accessibility is a crucial aspect to consider in a digital platform solution that is intended to be inclusive [6]. Web accessibility means that persons with disabilities can use the web as much as possible without any barrier, regardless of their disability (visual, hearing, motor, or cognitive). In this sense, over the years, there have been efforts worldwide to create directives and recommendations related to digital accessibility standards by publishing ISO standards that cover the various dimensions of digital accessibility. The Web Content Accessibility Guidelines (WCAG) were published in 1999. When this research started, WCAG 2.1 was the latest version, consisting of four principles, 13 guidelines, and 76 compliance criteria. WCAG 2.2 was released in late 2023 as an incremental upgrade. Similarly, WCAG 2.1 was published in 2018 as an upgrade to version 2.0 to meet the new technological developments, adding specific guidance on mobile and success criteria that address low vision, cognitive, and learning impairment. It introduced four key principles that should be followed in creating web content that is accessible and usable for everyone: (i) Perceivable – information and UI components must be presentable and perceivable to all users; (ii) Operable – web or device interfaces and navigation should be operable in a variety of ways to make sure people with different abilities can use them; (iii) Understandable: content and user interfaces should be easy to understand by all; (iv) Robust: content must be robust enough that it can remain accessible even as technologies and user

[1] https://tomglobal.org/about

agents evolve. However, applying WCAG specifications to build a digital platform effectively raises several challenges [7]. For instance, making an application effectively accessible to a deaf person might make it less accessible to a blind person, and vice versa. Several studies suggest the importance of adapting user interfaces and content to their users [8]. Also interesting to consider is the work of Hristov et al. [9], who present a method for designing accessibility in creating dynamic web content on the websites of a university. The method is built on standards, principles, guidelines, accessibility criteria, and techniques for creating and validating web content, following the WCAG and the technical specifications for accessible, rich Internet applications. Another work focuses on researching accessible content of educational websites to ensure and measure their compliance with accessibility standards for visually impaired people [10], studying standards' applicability on educational institute websites.

A few initiatives of web platforms are designed specifically to facilitate the acquisition of services for PwD. Most of the initiatives for designing web-accessible interfaces are within the scope of web educational platforms and are not specifically services platforms [11]. Services platforms are usually grouped into three categories according to what they deliver [12]: i) transportation; ii) offline services; iii) online services. In Taiwan, a platform called Eden aims to provide point-to-point transit services by connecting elderly and disabled passengers to drivers in Taiwan. According to [13], the platform provides flexible, custom-oriented services, where passengers can update their personal information in the system according to the diagnosis given by the physicians and where drivers can give feedback on the conditions and problems of passengers. However, no reference exists that the mobile app developed for passengers provides adapted user interfaces tailored to support specific needs. Another interesting initiative is reported by McLoughlin and his colleagues [14]. They present a case study of a web platform that works similarly to Trip Advisor by providing a means through which disability service users can share information about their experiences to inform subsequent choices. This case study was conducted in Australia and has shown the importance of this kind of web platform in empowering persons with disabilities.

2 METHODOLOGY

The adopted methodology for this work is participatory design [15] [16], which has been successfully employed in various Internet intervention projects [5] [17] [18]. This approach actively involves the individuals whom the outcome of the design process will directly impact, which is especially crucial when the intervention targets special groups [19]. By adopting a participatory mindset, designers shift their focus from their own experiences and expertise to the specific needs and requests of those with special needs or limitations [20].

In collaboration with partner entities, a multidisciplinary research team was assembled to ensure an inclusive and user-centred approach. Additionally, a set of key users was identified, and they were actively involved throughout the entire platform design, development, and evaluation process. Their invaluable insights and feedback helped shape the platform in order to better meet the needs of the target user group. This methodology ensured that the platform's design and functionality were informed by the actual experiences and requirements of the end users, ultimately enhancing its usability, accessibility, and effectiveness. This collaborative process ensures that the platform's development and implementation are grounded in the lived experiences of the target users, leading to a more effective and meaningful solution.

Four main steps were settled as Figure 1 illustrates. The initial step towards the conceptual prototype creation took place during the TOM initiative. The second step involved partner entity selection and needs assessments. Step three was the SEU model design and the platform prototyping, while step four focused on the evaluation study.

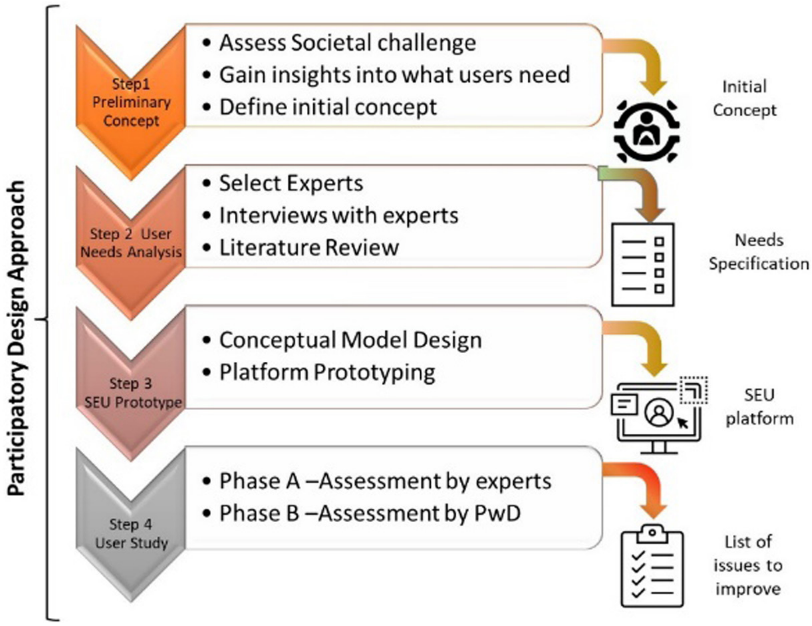


Fig. 1. SEU solution: steps of the design methodology

During **Step 1**, a team of computer engineering students, computer science researchers, and PwD worked together to develop a conceptual solution that ended up being a web platform to allow PwD to buy or book inclusive offline services. In two days of work, the ideation process included: exploring accessibility standards and existing technologies; analysing needs with the collaboration of PwD; exploring innovative functionalities (e.g., "the Friend place", an inter-help forum); and developing a non-functional prototype for proof of concept.

In **Step 2**, four partners were selected: (i) one organisation specialised in accessibility: Accessibility Portugal, which is a non-governmental organisation that aims to promote accessible tourism for all in Portugal; (ii) two organisations that support people with disabilities: APPDA-Setúbal, a non-governmental organisation dedicated to developmental disorders and autism and APPACDM de Setúbal, a non-governmental organisation for disabled persons, dedicated primarily to the area of intellectual disability; (iii) one health school specialised in rehabilitation and occupational therapy: Escola Superior de Saúde do Alcoitão.

These partners were key elements in the whole development process because, on the one hand, they contributed with expertise in disability accessibility issues and, on the other hand, they were the ones to build the bridge with PwD, who are the focus and the main end users of the intended solution. In this step, semi-structured interviews were conducted with the experts to identify and characterise:

(i) the general needs of PwD when they want to acquire an offline service through the web; (ii) the specific needs of each of the four PwD target groups. After the interviews, it was identified how the WCA2.1 standard answers the defined needs. In this step, an intensive study of the existing technologies on the market was also carried out, and we assessed how these could be used in software development to meet the specified needs.

In **Step 3**, leveraging the insights from previous steps, the initial version of the model for tailoring user interfaces to different types of disabilities was constructed. The survey of needs from step 2, together with the support of the partners, also led to the discovery of some specific functionalities that would ensure the support of a credible business model for the target population. Therefore, the SEU Services Model was introduced to meet the identified needs, alongside the development of the initial prototype version designed for services in the health and well-being sector.

Step 4 contemplates validating the prototype with experts and evaluating it with end users (covering different types of PwD) to assess the platform's usability for the different types of users. Usability tests allow observing the interaction of users with a system and may include both qualitative and quantitative data collection techniques. This user study was composed of two phases. Phase A aimed at providing an evaluation of the platform by experts, and phase B was focused on the end users, who were PwD evaluating the platform with or without the support of caregivers.

3 SERVICES TO EMPOWER YOU

The SEU web platform intends to provide multimodal interfaces that adapt to users' disabilities. The SEU concept was designed with input from human-computer interaction (HCI) experts, occupational therapists, accessibility experts and persons with disabilities, which led to the development of accessibility profiles for people with cognitive, visual, motor and hearing impairments. SEU was built in the context of Portugal. This section presents the design process of the solution and provides an overview of the SEU concept.

3.1 Needs identification

By analysing the interview content with experts as the first step of the process, it became possible to identify and describe the following main points:

- The potential users that would acquire offline services through the web platform.
- The set of needs of the clients regarding the specified service model.
- The factors influencing digital accessibility for each type of disability.

Regarding the theoretical service model, the web platform intends to respond to the needs raised by PwD when they need to acquire local services and rely on the physical presence of the service provider. Three main types of clients were identified: **Person with disability**, the main client of SEU, is a disabled person who can book a service; **Caregiver**, a person who books a service on behalf of a person with a disability; and **Supervisor**, who is responsible for remotely supervising the purchase of a service by a PwD (usually cognitively impaired) who, due to safety concerns, requires supervision of their decisions to book a service.

The main needs regarding features provided by the solution are:

- Users can search for services based on location, category, and adaptation type. Detailed information about available adaptations for each service is crucial for clarity and helps users assess suitability for their needs.
- Supervisor approval is required to confirm services booked by PwD clients.
- A face recognition sign-in is required to avoid password memorisation.

The main challenges related to digital accessibility were identified for each type of user as follows: **Users** with: i) **visual deficits** may have difficulty seeing or have low vision, so they may struggle to use the mouse when interacting with the computer; ii) **hearing impairments** may experience difficulties hearing or have poor hearing, presenting variations in their ability to read or write and fluency in sign language; iii) **cognitive deficits** may face a range of challenges, including limited or no proficiency in reading and writing, difficulty understanding complex information, decision-making challenges, and memory impairment; iv) **upper limb motor deficits** may encounter difficulties using the mouse, keyboard, or even speaking in some cases.

3.2 Conceptual model

The following main dimensions have been addressed to respond to the needs identified in Step 1:

- Identify primary adaptations needed for each type of user with a disability.
- Implement suitable information and mechanisms for distinct personalised interfaces.
- Include essential features to support the acquisition of offline services by PwD.

A set of guidelines was proposed by considering the characterisation of each type of PwD regarding the main aspects that may condition digital accessibility, including:

- **Authentication (sign-in):** It is essential for web applications to verify user identity. Typically, it involves username and password combinations, which can be challenging to remember securely. Face recognition and fingerprinting offer simpler alternatives to enhance security and user convenience.
- **Page layout:** Page layout greatly influences user perception and navigation ease. Single-page formats simplify navigation, aiding screen reader users and those utilising keyboard shortcuts. However, long pages may pose challenges for individuals with cognitive impairments. If using a long-page format, including a “return to top” option can enhance navigation.
- **Form layout:** Forms are vital for web pages, enabling users to input data sent to servers for processing. Accessibility aspects like label font size, colour contrast, element alignment, and navigation mode within the form are crucial. Tailoring to different user needs is key. As for blind users, Alt-Key navigation and clear

labeling are essential for screen reader usability. Short forms requesting only essential data aligned in a single column are recommended for those with cognitive impairments.
- **Input fields:** Various data input components should be used, with special attention to text fields for text input. Each field should have a clear label to aid screen reader functionality. A dictation option can assist users with low literacy, while explanatory labels/icons can aid users with cognitive deficits in understanding the required text.
- **Text:** Web pages often include descriptive texts. However, it is important for users with reading difficulties to provide the option to listen to the text. Additionally, for users who struggle with complex written or oral communication, simplified texts supported with images and pictograms should be made available [21] [22].
- **Image:** It is important to provide clear and detailed descriptions of the images so the screen reader can work efficiently (following guidelines on describing images effectively [23]). For blind users, this is the most critical issue. It is best for users with cognitive impairments to use simple images, photographs with plain or blurred backgrounds, or pictograms to facilitate comprehension and avoid distraction [22].

In order to provide personalised UI, web platforms must store specific accessible content, such as videos with sign language, simplified textual descriptions, and pictograms. Additionally, it is crucial that each adapted piece of content is linked to the original component it corresponds to. For example, if a page has text describing a service, the description should be accompanied by associated sign language videos, simple textual descriptions, and image(s). It ensures users with different impairments can access the content they need, with the adapted content being linked to the original. A component for managing accessibility content is included to address these challenges. Figure 2 illustrates the conceptual model of the SEU platform, which includes representations of users as well as the key features of the offline services platform.

The conceptual model comprises three distinct categories of users: i) **Clients**—who seek to acquire a service or oversee its acquisition; ii) **Service providers**—offline service providers like health, transportation, and beauty services; iii) **Platform managers**—responsible for managing the platform, including actions such as approving or disapproving registrations and managing accessible content. Moreover, the SEU platform integrates a range of key features:

- **User sign-up:** This feature allows all users to sign up and create accounts.
- **Service registration:** Service providers can register their services and specify adaptations for individuals with disabilities.
- **Service booking:** Clients can search, view, and book services offered by registered service providers.
- **Approval of registrations:** The platform manager is responsible for approving client, service provider, and service registrations.
- **Accessible content management:** The platform manager can upload extra digital elements, like simplified text, pictograms, and videos with sign language translation, to create adaptive interfaces.

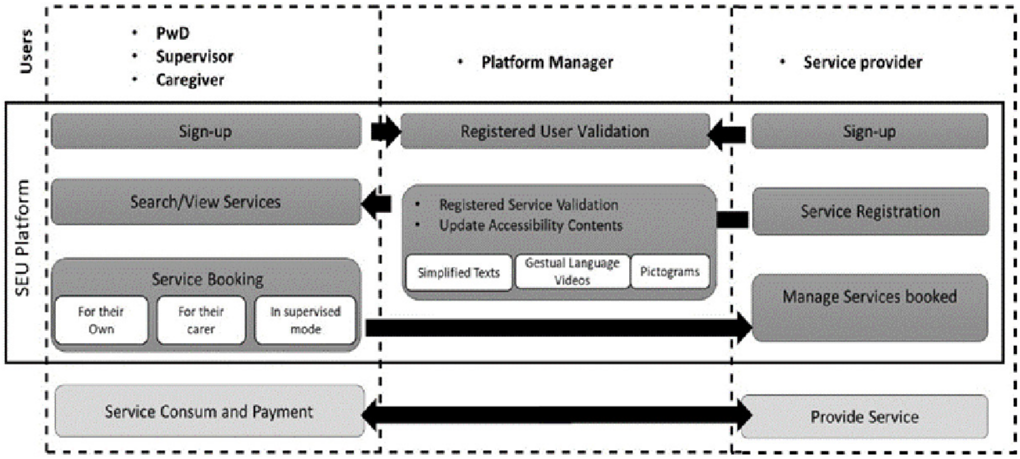


Fig. 2. SEU platform: conceptual model

4 SEU PLATFORM PROTOTYPE

The platform presents a client-server architecture based on *RESTful* web services. *MongoDB* serves as the data repository, while *Node.js* and the *Express.js* frameworks are used to implement the server and service logic layer. Additionally, *Vue.js* was used to ease the client-side development, responsible for displaying the user interface in a web browser.

User interaction on the SEU Platform aligns with one of four adaptation profiles from the conceptual model. Users choose from available adaptations before continuing if a profile is not set (e.g., the auditory profile offers LGP (Portuguese Sign Language) videos detailing features and services (see Figure 3)). On the other hand, the cognitive profile employs simplified text, images, and icons for clarity (see Figures 4 and 7).

Figures 4 and 5 illustrate how the SEU Platform's sign-up form is adapted for hearing-impaired and visually impaired users. The form can be further customized for each of the four impairment categories. It is presented on a single page to reduce navigation and is configured for easy keyboard access with screen readers for visually impaired users. Speech input is available to aid users with typing difficulties. For hearing-impaired users, the form is divided into five steps for clarity, which is especially beneficial for those with weak reading and writing skills. Simple labels with examples are provided for clarity. Additionally, facial recognition is provided to guarantee an easier login process (see Figure 6).

The motor and cognitive interfaces share the same layout, with colour changes based on the selected adaptation. Voice dictation is available for filling fields, like the visual interface, and it is divided into stages, like the auditory interface. When clicking on a field, the computer reads the required input, accessible via mouse or keyboard navigation using the tab key. Caregivers or supervisors can also use a non-adapted interface for the user.

Additionally, each service on the platform includes details about the available adaptations (see Figure 7), ensuring clear and accurate information to PwD to help them determine service suitability. The information can also be used to filter services during platform searches, facilitating PwD in finding and accessing relevant services.

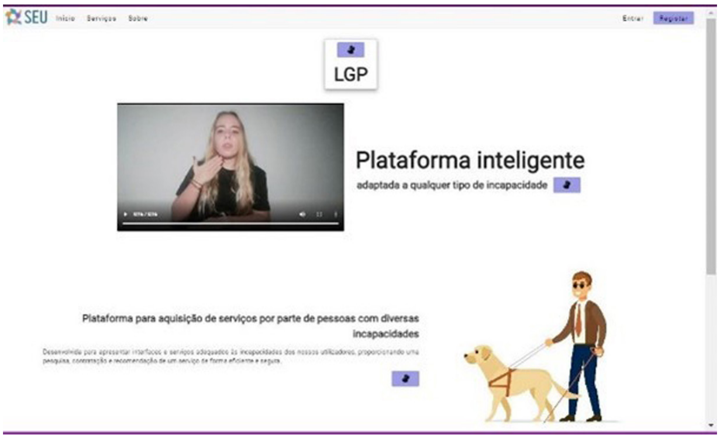
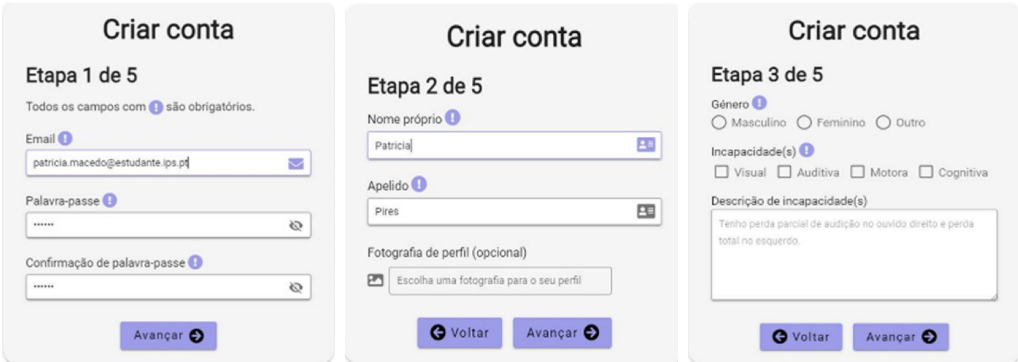


Fig. 3. SEU's auditory adaptive mode with sign language videos



a) Email and password **b) Name and optional photo** **c) Gender and impairments**

Fig. 4. Part of the sign-up form adaptation for users with hearing impairments

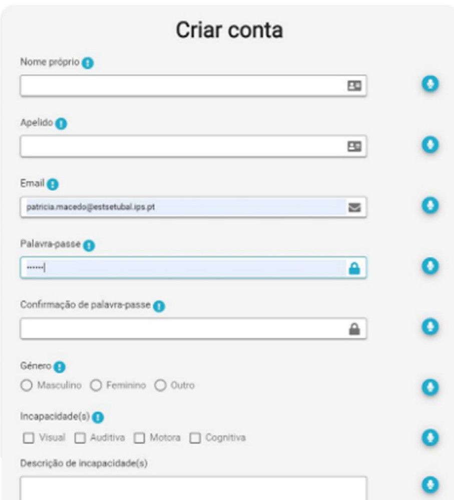
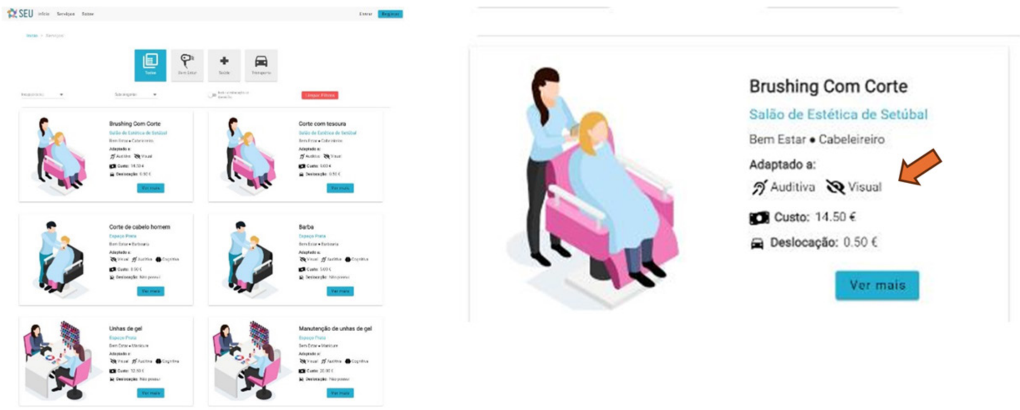


Fig. 5. Part of the sign-up form adaptation for users with visual impairments

Fig. 6. Face recognition login

Any platform user can view the services, but only users who are logged in, whether autonomous, supervised, or caregivers, can request a service. Service providers must include details about supported adaptations when adding any new service to the platform, subject to validation by the platform manager. Adjustments may be necessary to meet SEU Platform accessibility standards, such as uploading sign language videos for service descriptions. Service providers also may require information about user characteristics to accommodate their needs, ensuring service accessibility for all users.



a) Search Form b) View Summary Information

Fig. 7. Services of SEU display the target group to which they are adapted

5 EVALUATION

A user study was conducted in two phases to evaluate the accessibility and usability of the SEU platform. Phase A focused on assessing the platform by experts (occupational therapists and accessibility experts), while phase B involved a group of persons with disabilities testing the platform. The two phases are detailed as follows:

5.1 Phase A

Protocol and participants. The expert evaluation consisted of performing a set of tasks using different adaptation profiles (visual, auditory, cognitive and motor). For each profile, the experts filled out a questionnaire to give their opinion on the accessibility of each implemented feature. Four experts participated in the user study, including an autism-specialised therapist, two Ph.D. professors specialised in occupational therapy, and one expert in accessibility.

Upon conclusion of the tasks, each participant was asked to complete an online questionnaire, where the platform's concept and usability were evaluated. For each task performed, the participants provided feedback and recommendations for improvement in a qualitative manner.

Results. Based on the detailed feedback received from the experts, the following specific updates were made to the platform:

1. **Combo box replacement:** The combo box used to select the date for booking a service was identified as cumbersome, especially for users with motor impairments. It was replaced with separate text fields, allowing easier and more precise input.
2. **Reordering of page elements:** Experts suggested that the sequence of elements on certain pages was confusing and hindered navigation. As a result, the order of

elements was adjusted to follow a more logical flow, improving the overall user experience.

3. **Inclusive images:** Feedback indicated that the images associated with the categories of services were not representative enough of the diverse needs of users. We updated these images to be more inclusive and reflective of various disabilities, enhancing clarity and relevance.
4. **Facial recognition for sign-in:** A facial recognition feature was added for sign-in to address difficulties faced by users with motor impairments when using traditional input devices. This feature simplifies the authentication process for these users, making it more accessible and user-friendly.
5. **Cognitive mode usability:** There were several comments about the usability of the cognitive mode. Experts noted that users with cognitive disabilities have a wide range of skills and challenges. To address this, we simplified the language used in the cognitive mode, increased the use of visual aids, and implemented step-by-step guidance to support users with different levels of cognitive abilities.

The updates were implemented to address the specific issues raised by the experts, ensuring that the platform is more accessible and user-friendly for all users.

Furthermore, the results obtained from the questionnaire revealed some issues regarding the effective usability of the interfaces when the cognitive mode is selected since users with cognitive disabilities have a very distinct set of skills and difficulties. Cognitive disabilities can vary widely, encompassing a range of conditions that affect an individual's ability to process, retain and retrieve information. Some of the most common cognitive disabilities include intellectual disabilities, memory impairments, and attention deficits. Individuals with cognitive disabilities may experience difficulties in planning, problem-solving, decision-making, and information-processing tasks. Given the diverse range of cognitive disabilities, it can be challenging to create a single interface that caters to all users with cognitive impairments. Designers must be aware of the different needs and challenges of each person with cognitive disabilities and tailor the interface to address them. It is crucial to ensure that the platform's design is simple, clear, and easy to navigate, emphasising visual and auditory cues, plain language and straightforward instructions.

5.2 Phase B

Protocol and participants. In phase B, tests involved completing specific tasks, followed by a post-test questionnaire. In collaboration with an organisation for PwD, the project was promoted among their members, leading to the recruitment of volunteers. Study participants had to meet inclusion criteria: age 18 or older, diagnosed as PwD, and proficient in computer use; institutionalised individuals were excluded. Custom scripts were prepared for each user type, with sessions conducted individually lasting approximately one hour. Researchers observed without interference, noting user actions to identify areas for improvement. Active observation provided valuable insights into the user experience. After task completion, users filled out a questionnaire assessing satisfaction with platform features and overall usability, measured using the System Usability Scale (SUS) [24], employing the European Portuguese version [25]. The questions consisted of Likert items with a scale of *1 (strongly disagree)* to *7 (strongly agree)* for the ten standard SUS statements, and the domain-specific statements focused on each task presented to the user.

Eight participants from the Center for Supporting Independent Life (CAVI) were involved, along with three personal assistants, to simulate real-world support scenarios. These tests aimed to gauge platform usability and accessibility from the end-user's perspective. Depending on participant characteristics, sessions lasted from thirty minutes to over an hour. All participants used a laptop with the Chrome browser, with computer distance adjusted for comfort, accommodating wheelchair users (see Figure 8).

Regarding the external assistive technology, one participant utilised the NVDA (NonVisual Desktop Access) screen reader, while two others utilised pointers, and an additional participant used an eye-tracking device. At the beginning of the test, we briefed each participant with an explanation of the platform's purpose and presented an overview of its key features. We then presented a script the participants were asked to follow during the test. Participants with cognitive disabilities who had no autonomy to follow the written script required a more detailed explanation of each task.

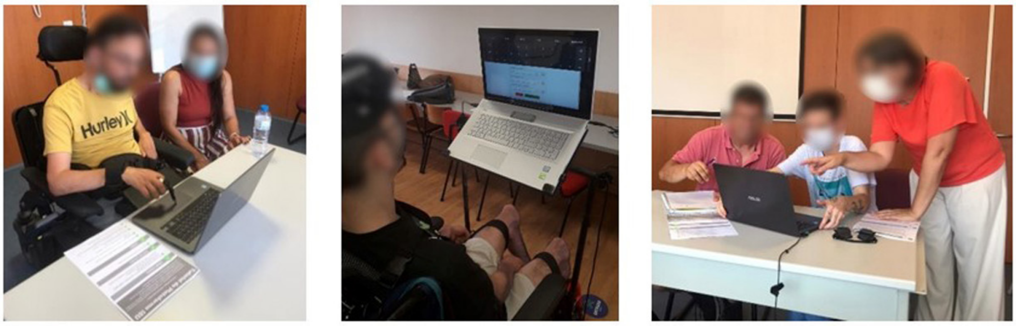


Fig. 8. User study's phase B with participants 1, 4 and 5 (from left to right)

Participants needed to be on the SEU Platform and have chosen their adaptation to be eligible to follow the script. The script defined the following six tasks:

1. **Registration:** The participant should have previously created an account to log in to the platform. They needed to choose to register and be at least 18 years old to create this account. After the registration, a popup message appeared informing about the successful registration. This task could have been done in the session by two types of participants: autonomous users and supervised users.
2. **Login:** The participant can log in once the account is created.
3. **View profile:** After being logged in, they could view their profile. Afterwards, they were required to update it by changing at least one of the account details. In the event of success, a notice would appear indicating it. Following this step, the participant had to change her/his password. Once again, a notice would appear indicating it in case of success. After that, it was requested to add a picture for face recognition, and another notice should appear in case of success. Finally, participants were instructed to try logging in with facial recognition.
4. **View services available:** Under this task, participants were asked to view the available services on the platform. To do so, they had to access the services tab, view services by category, and finally view a specific service by pressing: view more detailed information about it.
5. **Service booking:** With a service page open, participants were asked to book it simply by requesting the service. In case of success, a notice would appear indicating it. It was only possible to choose the dates made available by the

service provider. Lastly, they were requested to make one more appointment at a different service of their choice.

6. **View services booked:** At the end, participants could check the status of their orders and access more information about them on their profile page.

The participants followed the steps outlined in the script. At the same time, an observer from the research team registered information about their behavior, such as verbal commentary, body language, and any difficulties they encountered. Each user was asked to complete a questionnaire once the tasks were completed.

Before the testing sessions, each participant was assessed by the multidisciplinary team at CAVI and assigned a score based on a set of predefined competencies. These scores were used to categorise participants' language proficiency (both written and spoken), cognitive level, and digital literacy, ranging from 0 (none) to 3 (high) for each category. The detailed characterisation of each user can be found in Table 1.

Table 1. Phase B: Characterisation of participants

Participant	Disability	Birth Disability	Language Proficiency Written	Language Proficiency Spoken	Cognitive Level	Digital Literacy	Accessibility Mode	Monitored Mode	External Assistive Technology
1	Tetraplegic	No	3	3	3	3	Motor	No	Pointer
2	Tetraplegic	No	3	3	3	3	Motor	No	
3	Spina bifida	Yes	1	2	2	1	Cognitive	No	
4	Cerebral palsy	Yes	3	0	2	3	Motor	Yes	Eye tracking device
5	Cognitive Deficit	Yes	2	1	2	2	Cognitive	Yes	
6	Blind	No	3	3	3	3	Visual	No	Screen Reader
7	Tetraplegic	No	3	3	3	3	Motor	No	
8	Cognitive Deficit and Tetraplegic	Yes	1	1	1	0	Cognitive	Yes	Pointer

Results. Table 2 shows the results, where only six out of eight users could respond to the survey, as two of them were unavailable. One participant had other prior commitments, while the other was physically and emotionally fatigued.

Regarding the *Registration* task, all participants were able to complete it successfully. Users 4 and 5 did not perform this task since their personal assistants carried it out. Similarly, all users completed the login task without difficulty. However, during the *View Profile* task, two participants encountered difficulties. One found the task challenging, while the other required support from the observer to complete it. For the *View Services* task, only one participant had difficulty following the required steps. Finally, for the *Service Booking* and *View Booked Services* tasks, all the participants found the process very clear and easy to follow.

Table 2. Phase B: Usability test results

Participant	User's Observed Behaviours	Fill Out Survey	T1-Registration	T2-Login	T3-Viewprofile	T4-ViewServices	T5-ServiceBooking	T6-ViewBookedServices	SUS
1	Evidence of high proficiency using web interfaces. Gave advice for improving some UI issues.		7	7	7	7	7	7	80
2	Evidence of good proficiency using web interfaces.	Yes	6	6	6	6	7	6	77
3	Many difficulties using the keyboard and could not use the mouse. Some cognitive difficulties in following the instructions.	Yes	7	7	1	7	7	7	52
4	Understand all the process.	Yes	NA	4	7	6	7	7	87
5	Understand all the process. However, evidence of a lack of autonomy.	Yes	NA	6	3	6	7	5	71
6	Evidence of high proficiency using web interfaces. Gave advice for improving some UI issues.	No	Not available						
7	Evidence of high proficiency using web interfaces. Gave advice for improving some UI issues.	Yes	7	7	7	7	4	7	100
8	Many difficulties using the keyboard, could not use the mouse. Cognitive difficulties in following the instructions.	No	Not available						

Regarding the SUS results, the platform scored 77.78 on a scale from 0 to 100. Despite the small sample size of six participants, this score indicates a positive outcome, highlighting the platform's potential at its current stage of development. The score comfortably surpasses the minimum acceptable level of usability, typically set at 70 [26]. According to [26], the score corresponds to a solid C grade and approaches a B grade, while another study suggests it can be considered a solid B grade [27]. It is worth noting that participant 7, who has tetraplegia, scored 100. Observations during the task performance revealed that this participant demonstrated a high proficiency in using computers, justifying the exceptional score. On the other hand, participant 3 received the lowest score due to inherent limitations, which contributed to a lower overall SUS score. These findings indicate a direct correlation between the participants' digital literacy levels and their usability scores, with participants 3 and 5, who have lower levels of digital literacy, obtaining the lowest scores.

6 CONCLUSIONS AND FUTURE WORK

The SEU concept aligns with the principles outlined in the United Nations CRPD, emphasising the role of information and communication technologies in promoting the rights and well-being of persons with disabilities. The SEU Platform has been developed to address accessibility and usability challenges faced by PwD when acquiring offline services that require physical presence. Through a participatory design process involving input from experts and PwD, the platform provides a comprehensive solution that promotes inclusivity, enhancing the user experience.

The platform offers multimodal web interfaces tailored to different types of impairments, including cognitive, visual, motor, and hearing. By storing specific accessible content such as sign language videos, simplified textual descriptions, and pictograms, the platform ensures that users with diverse impairments can access the content they need. It caters to three main types of clients: persons with disabilities, caregivers who book services on their behalf, and supervisors who remotely supervise the service booking process for cognitively impaired individuals.

Feedback from experts and end users participating in the user study was very positive, highlighting the platform's important features and well-designed interfaces. User tests conducted with individuals from CAVI demonstrated the platform's acceptance of usability. Participants successfully completed various tasks, including registration, login, profile viewing, service browsing, booking, and viewing booked services. While some participants encountered difficulties in specific tasks and required support, overall, the platform could facilitate the acquisition of local services for PwD. The SEU platform achieved a positive SUS score, surpassing the minimum acceptable level of usability. It can be stated that the participants' digital literacy levels influenced their SUS scores, indicating the potential benefits of providing training and support in digital skills to enhance overall usability.

While the SEU platform exhibits promise in providing inclusive offline services, continuous refinement and consideration of diverse user needs are vital to reach effectiveness and improve inclusivity. The feedback provided by the experts during the first phase of the user study highlights the need to improve the platform's cognitive mode to ensure that it provides the best possible user experience for all users, including those with cognitive disabilities. It is essential to conduct further research and testing to determine how to optimise the SEU platform's usability for users with cognitive disabilities. Moreover, we should consider conducting user tests with persons with other disabilities or impairments, opening the scope of participants. We need to find greater representation within each type of disability.

Furthermore, an important future direction lies in developing smart interfaces to personalise the user experience based on individual profiles using machine learning techniques. Usually, the implementation and design of a computer system are carried out considering its target audience, where one or a few generic profiles are characterised. This idea is interesting because, through a relatively small effort rate and low cost, it is possible to define a software design corresponding to a user experience that satisfies practically all users. However, this approach is not practical when the target audience is not homogeneous, and there is a need to adapt the system to each individual or when the application is intended to take care of presenting the best possible user experience for each specific person. In the above situations, it becomes necessary to characterise the users in a more particular and personal way through different analysis techniques of the user profile. There are three essential steps in the process of designing adaptive interfaces that we should take [28] [29]: i) User data collection process; ii) User model construction process; and iii) User adaptation process.

Additionally, some participants indicated that having a mobile interface would be very good, as they are more used to smartphones daily. Mobile technology has recently made noteworthy progress in integrating computer technology to enhance electronic information, communication, and touch-screen accessibility [30]. There are examples of inclusive features and third-party applications designed to support individuals with visual impairment in carrying out their daily activities, fostering independent functionality, facilitating movement, promoting social inclusion and participation, and enabling access to education, among other aspects of life. These technologies are designed with universal accessibility in mind, ensuring that they do not contribute to social stigma or evoke negative reactions from peers or the public [30]. Mobile devices serve not only as communication platforms but also as valuable tools for aiding individuals with their daily activities. Mobile devices and apps provide PwD with endless opportunities, such as combining a streamlined data-gathering process, the Internet of Things (IoT), and cloud-based computing to meet their healthcare needs [31]. Therefore, developing for mobile devices will also help us reach the goal of keeping the focus on the individual through the implementation of personalised user interfaces.

Finally, SEU was built in the context of Portugal, involving Portuguese stakeholders, but we consider that the results and lessons learnt from the process can be perfectly followed in other contexts, given that accessibility issues are universal. However, there will always be language issues and cultural aspects to analyse when adapting SEU to another country since they may affect how users interact with the platform and the process of acquiring services.

7 ACKNOWLEDGMENTS

The authors acknowledge the individuals with disabilities and health professionals who generously participated in this study. Special thanks to the collaborating non-governmental organisations (APPACDM Setúbal and APPDA-Setúbal) for their support and to the students Patricia Paquete and Catarina Castro for the development of the essential components of the platform. This research was funded by Instituto Politécnico de Setúbal (reference SEU).

Informed consent was obtained from all subjects involved in the research and studies.

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