A MODEL-BASED APPROACH TO ENHANCING WEB ACCESSIBILITY FOR INDIVIDUALS WITH SPECIAL EDUCATION NEEDs

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Abstract: An important aspect in software development nowadays is digital opportunities for meeting the needs of disadvantaged affected people with Special Education Needs (SEN). In this article, we consider the problem of identifying and improving the accessibility of web platforms designed for users who have SEN. To achieve this goal, a model was created and implemented in the web platform sopbg.org. The specialized website, which is maintained and developed by the authors of the publication, unites a community of several thousand users with SEN. The intensive consumption of the platform provided the authors with the opportunity to make a number of improvements to the applied model, some of which should be considered.

Key words: accessibility, autism, dyslexia, special education needs, web testing.

1. INTRODUCTION

One of the problems in ensuring the accessibility of information in the Internet is the emphasis mainly on problems for people with impaired vision, hearing or motor problems, and not enough attention is paid to people with other specific needs

In this article, we consider the problem for the development of accessible web content for people with physical disabilities and with special education needs (SEN) such as autism or with dyslexia. Improving the accessibility of web content for people with special educational needs means first improving accessibility for disadvantaged and disabled people, then improving accessibility for the person with a special educational need. This means first developing content for users who have physical disabilities, such as reduced vision, hearing, mobility, etc., and then making that content accessible to users with mental and cognitive disabilities [1]. In software development, however, at certain stages these processes run in parallel.

The purpose of the publication is to present the creation of a model for increasing accessibility, the development of software based on the model, and the integration of the applications into a website. To achieve this goal, a model was created and implemented in the web platform https://sopbg.org/. The specialized site is an educational web media of the largest community in Bulgaria for people with spatial educational needs, united in the group https://www.facebook.com/sopbg.org/, which includes both people with disabilities and various medical specialties. The user experience of the site is designed for the needs of children with special educational needs. As a significant part of the community is associated with dyslexia and autism, there is a need to improve the level of accessibility for both people with physical disabilities and people diagnosed with dyslexia and autism. Dozens of community members were involved in the integration of the software to improve accessibility on a website. The website has its own trademark, which is patented as a co-authorship with the University of Plovdiv [2]. Web Accessibility Initiative (WAI) maintains a list of legislative acts for Australia, Canada, China, European Union, Japan, USA, etc., according to which websites and applications of public institutions and organizations must maintain mandatory or recommended levels of accessibility [3, 4] meeting specifications with requirements according to Web Content Accessibility Guidelines (WCAG). Both in the normative acts and in the technical specifications, the issues of autism and dyslexia are poorly addressed. For these reasons, a development and integration model was created based on personal experience and the needs of the sopbg.org community.

2. RELATED WORKS

Autism and dyslexia are often misclassified as childhood disorders, they are lifelong and therefore need to be considered in adult users, not just children [5]. They fall under the specific disorders of the ability to learn and perceive the surrounding world. Reading problems are referred to dyslexia condition. The following groups of issues are present: substitution and mixing of phonetically close or graphically similar characters, literal or syllabic reading, impaired understanding of a reading text and agrammatism when reading a grammatically correct text [6]. Autism is the presence of communicative disorders of phonetic language, although it also includes many other symptoms and manifestations. Autism spectrum disorders belong to an umbrella term category consisting of five childhood-onset conditions known as Pervasive Developmental Disorder (PDD): childhood autism (before age 3), atypical autism (onset after age 3), Asperger's syndrome, childhood disintegrative disorder. The creation of specialized web content for people with SEN is often developed without meeting the required level, needs and good practices [7–9]. For people with SEN, the problem of the protection of the data when the site or mobile systems is used by people with SEN deserves special attention [10, 11]. These issues can be resolved by initiating specific appropriate design, development and testing of accessibility web content. In the specialized literature, there are numerous

publications on the successful development of accessible web content [12-15]. Although the problem of the design of accessible web content for people with autism and dyslexia has been studied in detail, in the specialized literature in the field of technology, no studies have been noticed that integrate present it as a model for creating specific theory and web application with accessible web content.

3. THE PROJECT "CHILDREN WITH SEN".

The Children with SEN project is a web application that aims to assist and support children with specific learning difficulties caused by SEN status, as well as their parents and teachers. The start of the project began in early 2011 and was aimed at children in Bulgaria, but in 2012 the application was translated into English to help and support people around the world. The project was developed in order to provide appropriate training for active work on the development of creative skills and socialization of each child with dyslexia in the community and his preparation for school. The user experience of the site: sopbg.org is specifically designed for the needs of primarily children with SEN. Through the community in social networks, communication between schools, teachers, parents, specialists, and public institutions is carried out. Integrated education for children with special educational needs (SEN) is such education, in which the child, regardless of his disability, is included in the general education environment. However, this is achieved in conjunction with individual training programs, teams of specialists, didactic materials, and textbooks. Until 2018, difficulties and disabilities were not measured by accessibility testing approaches in the web application. So, we had to start from scratch and test the app and improve its performance and look for the people concerned. As a result of the changes made, the sopbg.org community has increased its members, contributors, experts, etc. The site https://sopbg.org/ is a community web media. It has the typical features of a website. Its main task, however, is to provide and share relevant information and resources to community members.

4. DESIGN AND IMPLEMENTATION APPROACH

Why and who needs accessibility? People with hearing impairment or blindness, partial or complete blindness, color blindness, people with motor neuron disorders, all age- related problems - all these people rely on software that they can use and make them feel more as part of society. In the last 10 years in the US there has been an increase in the percentage people with disabilities from 12.7% to 13.2% of the total population of the country. That's nearly 45 million people. In the European Union people with some forms of disability are around 70 million. These numbers are significant enough for us to understand the social importance of an accessible software product [16, 17].

The development of an authored application and the integration of accessible web content for people with SEN is realized through the agile iterative methodology of Extreme Programming (XP). Major iterations defined the model by which

functionality would be developed and integrated. These stages included developing a responsive design, developing an automatic text reader, implementing a specialized font, developing font resizing, and changing contrast. For the individual stages, the full cycle of activities of the XP methodology is realized. The methodology was chosen due to the nature of the sopbg.org project: it is developed for an ideal purpose, without payment to the team, it works in a lot of their cooperation, the organization of work is not formalized, etc. Among the main features, why XP was chosen over other methodologies is the central place it places on the testing phase. Although development testing of accessible web content is part of the software process, this activity is separate from software product quality testing [1]. The stage that preceded the development is related to the selection of literature materials for people with SEN. Thus, the model for developing accessible web content for people with autism and dyslexia consists of the components shown in Figure 1.

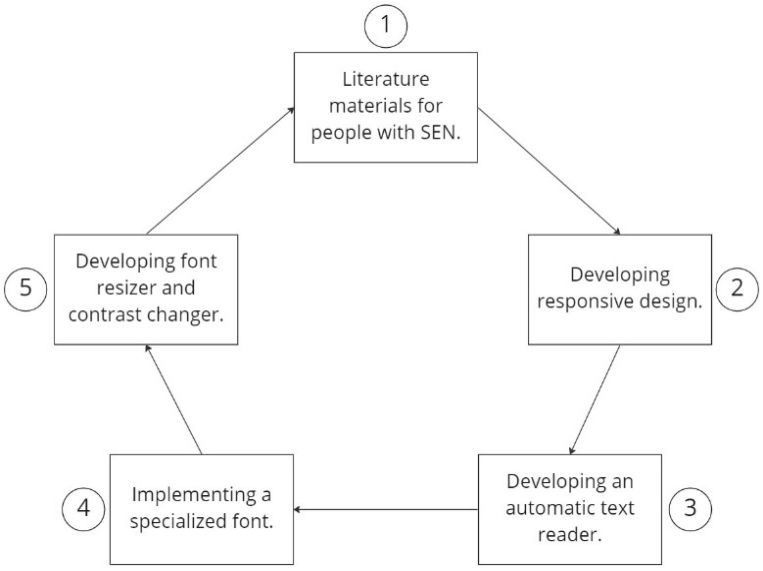

Figure 1. The model for developing accessible web content for people with autism and dyslexia

■ **Literature materials.** The design and implementation of the model under consideration first of all consists of the selection of appropriate educational content and its integration into a web environment. In the most general case, the creation of specialized web content for people with SEN consists of: Literature materials aimed in this area; Interactive logical and didactic media games through web and mobile; Specialized tests with a psychological focus, which are licensed and certified in the practices of teaching people with SEN. On the sopbg.org platform, materials are curated by members of the social network community who are proven educators with experience in the field.

■ **Developing responsive design of the application for mobile devices**. After an analysis done in 2018, we found that more than half of the visitors to the application log in via a mobile device, and this necessitated the addition of a responsive design for mobile devices. However, responsive design is also a prerequisite for quality development of accessible web content.

■ **Developing Screen Reader through the app**. We implemented a script that interacts with the google API library for connection with reading text. In this way, people with impaired vision have the opportunity to listen to the materials provided in the application, the text reader works both in Bulgarian and in any language of our choice. The screen reader tool is presented in Figure 2. The screen reader development and integration scenario in sopbg.org is discussed in detail in the next section.

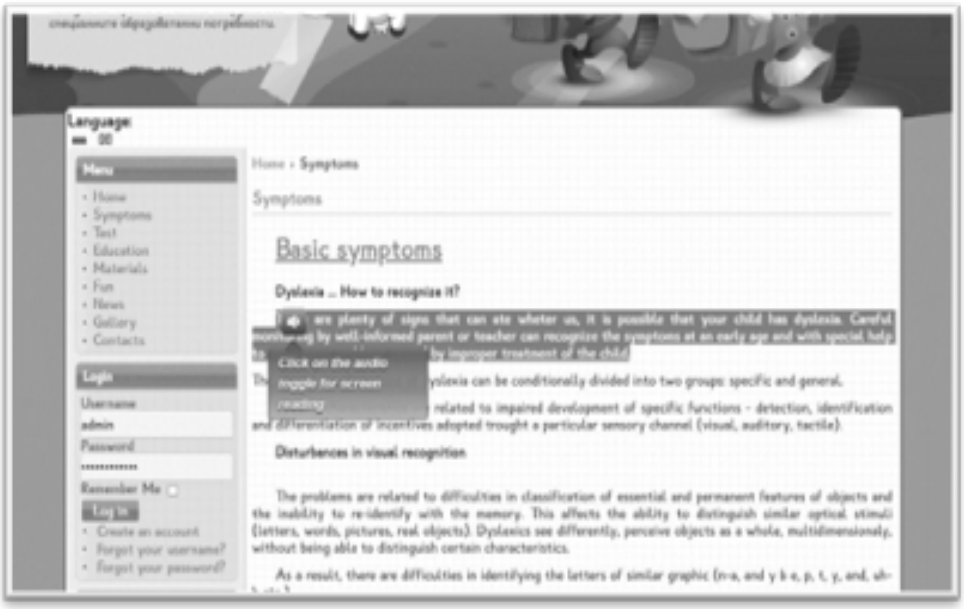

Figure 2. Screen reader functionality

■ **Implementation of specific font for dyslexic people**. We have managed to integrate a specialized font for people suffering from the condition of dyslexia. "Adys" is the first font for people with dyslexia. It serves the languages of Western, Central and Eastern Europe – it contains Latin and Cyrillic language tables, as well as many mathematical signs and symbols. This makes it suitable for creating training materials for all ages. And it is especially important for the youngest readers. "Adys" font contains Bulgarian form of Cyrillic [18]. This font facilitates easier reading by such people, as well as some people with other SEN conditions.

■ **Developing font resizer and contrast changer**. We have developed a program to resize the text in the application, through this assistive component, affected people with SEN have the opportunity to resize the text they are reading and thus facilitate the absorption of the materials. They have the ability to increase or decrease the size of the text material they are reading. We also added the ability to change the contrast of the text, again for better reading comprehension, because there are groups of people with SEN who need different contrast of the text presented. Also, added virtual keyboard navigation for better usability and basic text functionality for better view. A view of the implemented accessibility tool is shown in Figure 3.

Figure 3. Accessibility panel with font resizer and contrast changer

5. SCENARIOS FOR DEVELOPING SCREEN READER

The implementation of Screen Reader for web site and application involves a number of features. It is necessary that the site and the application follow good practices in web design, that the development adheres to the Web Content Accessibility Guidelines (WCAG) and User Agent Accessibility Guidelines (UAAG) of The W3C Web Accessibility Initiative (WAI), that external services of application program interface (API) are used, etc. In addition to needs of website sopbg.org, we integrated Google – text to speech open library and programmed it via PHP and JavaScript programming languages. It also utilizes the Google Text-to-Speech engine, parser and media capabilities to allow users to hear the selected text.

A scenario for developing a Screen Reader

1) The user visits the website and choose a form which contains text area, where can select the text, he wants to hear.

2) Using JavaScript, the user selects the text and clicks on a button with audio icon.

3) The JavaScript code on the page sends an HTTP request to the server-side PHP script, passing the selected text as a parameter.

4) The PHP script receives the request and uses the Google Text-to-Speech API to convert the text to speech, passing the selected text and other parameters such as the desired voice and speed.

5) The Google API returns an audio file containing the spoken text, which is passed back to the JavaScript code on the web page.

6) The JavaScript code then uses the browser's built-in media capabilities to play the audio file, allowing the user to hear the selected text read aloud. The user can now hear the text and understand the content of the page, even if he has hearing disorders.

In addition, the PHP script use a parser to analyze the text and adjust the Text to speech engine parameters like speed, tone, and volume to make the text more hearable. In this way, the web-based website provides a convenient and accessible solution for people with hearing disorders to access written content on the Internet.

Figure 4 shows the implementation of the scenario in which users can use the function.

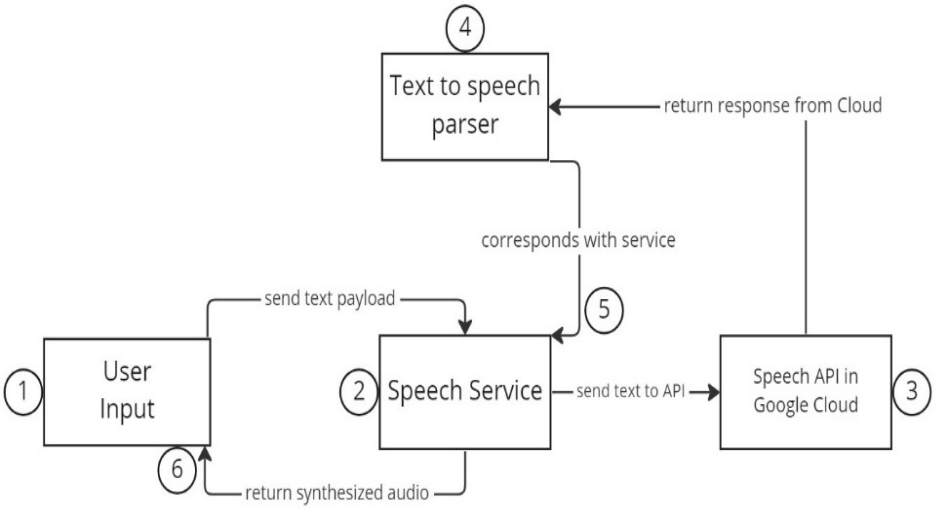

Figure 4. A scenario for developing a Screen Reader into a website

6. TOOLS FOR IDENTIFYING ACCESSIBILITY OF WEB CONTENT ERRORS

There are several benchmarks to consider when testing the accessibility of web applications. These include labels, text contrast, hit zone size, user interface hierarchy, and dynamic font size. Ensuring that these aspects of the application are functional and easy to use can help to make the application more accessible to people with disabilities. When testing web applications before they reach their audience, we normally use different tools to help increase the accessibility of a products. Such tools are special keyboards, text-to-voice software, voice-to-text, magnifier software, and etc. [19, 20]. Text-to-voice, zooming, and adjusting display and text size are some of the main tools used when testing mobile devices for accessibility [21, 22]. To evaluate the quality of the mobile version of sopbg.org we used TalkBack for Android and VoiceOver for iOS, which are designed to help people with disabilities in their daily lives. TalkBack has five main gestures: explore by touch, swipe right, swipe left, swipe up or down, and double tap. VoiceOver has similar gestures: tap on touch, swipe right, swipe left, two-finger swipe up, and two-finger swipe down. Zooming can be activated with a double-tap using three fingers and can be moved up or down with a three-finger drag. Both Android and iOS also have options for increasing font size and using bold text to improve readability for users with vision impairments. To identify barriers and errors in the web version of sopbg.org we tested the accessibility of web applications using WAVE (Web Accessibility Evaluation Tool) [23], JAWS and MAGic. WAVE is a free, web-based tool that can be used to check contrast, headers and footers, HTML tags, labels, ARIA properties, and page structure, and to provide suggestions for improvement. JAWS and MAGic are subscription-based applications that can be used to provide text-to-speech, mouse followers, zooming, color inversion, and text color change [24, 25]. In some tests to evaluate the font, we used Microsoft 365 Word Enterprise, through which it can be used to check the readability, reading ease, pronunciation, and punctuation of text, as well as to identify issues with the overall structure of the text.

7. RESULTS AND DISCUSSION

The sopbg.org project, as a social idea, is among the most successful in its field. A larger community that unites people with SEN, teachers and specialists has not been noticed in the country. This opinion is shared both by narrow specialists and by representatives of government agencies directly related to the problem. Part of the success of our project is due to the implementation of accessibility testing and the innovations we made.

Objective indicators for increasing the quality of the service and materials that the project offers are the attendance of users and their opinion. Two categories of users from the group community at https://www.facebook.com/groups/sopbg/ participated in the application testing. One category consisted of active users who

did real tests and a second category of users who expressed opinions with recommendations and remarks. These opinions were particularly useful given the applied experience and specialist competence of the members. Receiving feedback from hundreds of users to date convinces us that the integrated solutions fulfill their purpose. At the end of 2022, a quality assessment survey by anonymous visitors was uploaded to the site. The results of the survey show that the casual visitor highly appreciates the site's services. However, these data do not yet have statistical value due to the small number of completed surveys.

The statistics and opinion of the user support the idea that inclusive design and accessibility testing are crucial steps in the development of digital platforms, and that it can lead to significant improvements in usability and engagement for users with disabilities. At the same time, however, our experience of developing and maintaining the web platform in close cooperation with a wide range of users from the social network community shows that there are no working models developed for this type of software functionality. Therefore, the integration of the functionalities we have discussed required us to develop a simplified model adapted to an agile software development methodology. As stated, the choice of work organization methodology in 2019 depended on affecting the testing phase as widely as possible in the software process. From the perspective of three years of experience in maintaining and administering the site, during which time periodic changes are made, we believe that accessibility testing is an activity that should be considered as a separate phase Therefore, we conclude the discussion by summarizing the contribution of the application of accessibility testing.

Benefits of Accessibility testing

• Improve the user experience for everyone: When organizations implement digital accessibility best practices and accessibility testing, they will likely discover and correct usability issues that affect all customers.

• Broaden market penetration: If a website is not accessible, a business misses out on the potential to serve 15% of global users who currently have a disability.

• Building an inclusive brand image: An accessible digital experience demonstrates corporate social responsibility, which helps a brand’s reputation. Commitment to accessibility testing shows a brand care about interacting with all people in a meaningful way.

• Improving automation efforts: Accessible sites and apps contain tags and other information that enable people with disabilities to navigate them. Automation efforts that support updates and testing rely on many of these same attributes.

8. CONCLUSION

The paper presented a model for improving accessibility adapted to specific needs, while our experience with the work on the sopbg.org project, protects the understanding that software testing and especially accessibility testing are approaches that never end, periodically we need to test, inspect, and ask for feedback

from the stakeholders in order to improve applications and reach more people. In this way, we facilitate persons with SEN and the absorption of information, logical and didactic materials, and the right training.

The model we presented was adapted for the current needs of the site's users. The changes have improved the application, making it accessible to people with SEN. This expanded its popularity and the ability to reach and help more people worldwide. Also, the feedback we continue to receive is in a positive direction. The improvements will not end here, as a future development, we have set ourselves the goal of developing a virtual interactive keyboard for interactions with the app.

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