ACCESSIBILITY ASSESSMENT OF MOBILE APPLICATIONS: THE CASE OF THE HOMINERE APP

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ABSTRACT

In this article, it is intended to analyze and evaluate the Hominere mobile application regarding its accessibility through manual assessment and automatic tools, guided by the accessibility criteria defined by the Web Content Accessibility Guidelines (WCAG). The automated evaluation with the support of various tools (WAVE - Web Accessibility Evaluation Tool, Access Monitor and SortSite Accessibility Checker and Validator) allowed the authors to identify common accessibility problems, such as missing or mislabeled buttons, non-descriptive links, or inaccessible images. The manual evaluation was complemented with TalkBack allowed the identification of specific accessibility problems that automated tools cannot detect, such as complex user interactions or problems related to visual design and layout. With the evaluation and its analysis, it was possible to identify solutions for the problems presented to make the application more inclusive and accessible, and also to verify that the selected accessibility strategy evaluation is effective and appropriated and can be replicated in the accessibility evaluation of other mobile apps.

KEYWORDS

Accessibility Assessment, Accessibility Principles, Guidelines, Mobile Application, Screen Readers, Web Accessibility

1. INTRODUCTION

With the increasing number of people with disabilities, accessibility has become a critical issue for designers and developers of digital products and services. Mobile applications have become an integral part of people's daily lives, and their usage has increased significantly in recent years. These applications serve as a medium for individuals to access information, communicate, and complete various tasks. However, people with disabilities often face significant barriers when using mobile applications due to accessibility issues. Therefore, evaluating mobile application accessibility is critical to ensure that everyone, including those with disabilities, can use them without any difficulties.

The accessibility evaluation strategies can be classified into two categories: manual evaluation and automated evaluation. Manual evaluation involves expert evaluators who manually inspect the product or service for accessibility issues, and automated evaluation comprises software tools that can automatically check the accessibility of digital products. Manual evaluation can identify accessibility issues that are difficult to detect using automated tools; however, this type of evaluation can be time-consuming and expensive. Automated evaluation, on the other hand, is faster and less expensive, but it may miss certain accessibility issues that can only be detected by human evaluators.

This article focuses on developing a hybrid evaluation strategy that combine both manual and automated evaluation, which can help developers and designers improve the accessibility of mobile applications and provide a better user experience for everyone.

In a context of Challenge Based Learning (CBL), in the school year 2022/2023, integrated in the Master Communication and Web Technologies from the Aveiro's University, it was proposed by the partner of that year – the company BOSCH – the development of digital platforms to reduce energy waste. One of the projects developed was Hominere, a mobile application that aims to solve the lack of motivation regarding energy and water saving and the lack of energy efficiency in people's daily lives, such as food, transportation, and recycling. Furthermore, the application also aims to change users' behavior in the mentioned areas, presenting a motivating and re-educating character through information-sharing publications. There is also the presentation of challenges that aim to help and guide individuals to change bad habits according to their needs.

In this way, in the scope of the Curricular Unit of Digital Accessibility and Compliance, of the mentioned master's degree, the evaluation and analysis of the Hominere app were carried out to detect possible accessibility problems and, through the results obtained, elaborate and present possible solutions to improve the final product, and also to understand if the selected accessibility strategy evaluation is effective and appropriated and can be replicated in other mobile apps assessments.

2. THEORETICAL BACKGROUND

Web accessibility is the degree to which a website/mobile app is usable by the most significant number of people to promote their digital and social inclusion (Kalbag, 2017). Therefore, web accessibility refers to the ability of people with disabilities to access and use digital content, including websites, mobile applications, electronic documents, and other digital resources. This means designing and developing digital content to be easily accessed and used by people with disabilities/incapacities, including those with visual, hearing, physical, cognitive, neurological or some temporary impairment (Cooper et al. 2016; Oliveira et al. 2021).

Digital accessibility is essential because it ensures that people with disabilities have equal access to information, services, and opportunities online. It also helps European organizations comply with legal requirements, such as the Directive (EU) 2019/882 on the accessibility requirements for products and services, also known as the European Accessibility Act.

The World Wide Web Consortium (W3C) defines web accessibility as "essential for developers and organizations that want to create high-quality websites and web tools, and not exclude people from using their products and services" (W3C WAI 2018). Digital accessibility involves ensuring that digital content is perceivable, operable, understandable, and robust for all users, including those who use assistive technologies like screen readers, magnifiers, and alternative input devices (WCAG 2.1). Digital accessibility also includes considerations for usability, such as providing clear and consistent navigation, labelling of form fields, and ensuring that content is easy to read and understand.

The compliance levels of a mobile platform/application depend on the priority check. Thus, the application is assigned conformance level 'A' if all priority one checkpoint is satisfied, conformance level 'AA' if all priority 1 and 2 checkpoints are satisfied, and conformance level 'AAA' if all priority 1, 2 and 3 checkpoints are satisfied (W3C WAI 2018). Accessibility assessment should be a process that combines automatic tools (software) and human assessment (Rutter et al. 2007). Following this line of thought, Slatin & Rush (2002) refer that no automatic tool detects all accessibility problems. However, in combination with a manual check, they are the starting point for problem detection and correction.

3. RELATED WORK

Developing an accessible app is still challenging due to several particularities of mobile phones requiring technical expertise in creating applications that meet the needs of people with disabilities (Ballantyne et al. 2018). Recent studies show that developers need to consider different specialties of mobile phones, e.g. versions of the same mobile operating system, different screen sizes, and the features of assistive tools such as screen readers like VoiceOver and TalkBack (Oliveira et al. 2021; Silva et al. 2021; Tymoshchuk et al. 2021).

In this context, several studies highlight the importance of accessibility testing in the prototyping phase is crucial for ensuring that mobile applications are accessible to everyone (Nilsson 2018; Silva et al. 2021; Vieritz et al. 2016). Dias et al. (2022) conducted a literature review of automated evaluation tools for web and mobile accessibility and despite the existence of various tools either for web or mobile apps, they are not completely effective, covering less than 40% of all the problems encountered. Also, no tool was found capable of adapting the application interfaces according to the type of disabilities that users may present. Ismailova and Inal (2018) carried out a comparison of online accessibility evaluation tools to perceive their effectiveness. The authors observed that each tool generated different evaluation data for the same websites and some of the tools are complementary to each other, meaning the highest coverage and completeness can be possible with the right combination of evaluation tools. Therefore, the authors suggest that different tools should be utilized to provide consistency and obtain reliable data from online evaluation tools, improving tool effectiveness.

Accessibility evaluation requires a deep understanding of accessibility guidelines, specialized knowledge and expertise, and adequate time and resources to conduct the testing properly. In this context, web development courses should offer future developers the opportunity to learn and apply in practice the accessibility guidelines that should be considered in the mobile app development process. Recent studies report that students of web/application development have a low level of familiarity with accessibility guidelines and their practical application (Kearney-Volpe et al. 2021; Cao and Loiacono 2022). These studies underline the importance of educating future developers about accessibility guidelines, promoting their personal connection with disabled people in the educational process, including universal design principles in the development of accessible websites/apps, as well as the business values of an accessible web/app.

4. METHODOLOGY

This study presents a work of accessibility assessment of a mobile app prototype – Hominere developed by five students of the master's degree Communication and Web Technologies, focuses on informing and motivating users for energy efficiency and water saving through challenges and a forum (Figure 1) that help and guide them to save more and change bad habits, depending on their needs.

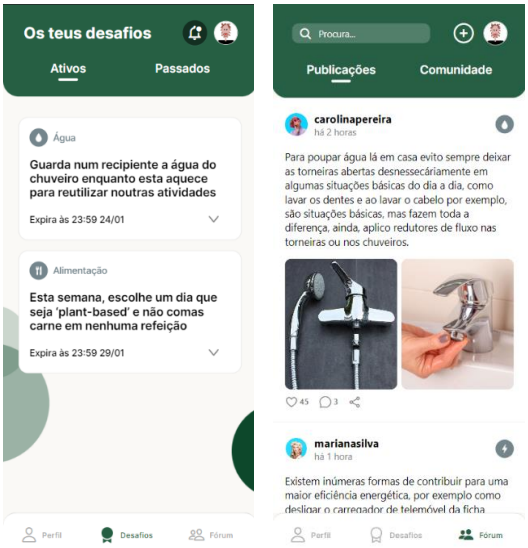

Figure 1. Challenges and Forum areas

To improve the accessibility of the Hominere app, the authors evaluated it by applying the following guidelines and automatic and manual evaluation platforms/tools:

1. Web Content Accessibility (2.1) and Mobile Accessibility (2.0) Guidelines

The analysis was ruled by a set of recommendations defined by the Web Content Accessibility Guidelines 2.0 (W3C WAI 2018), following its principles, guidelines and criteria applied to the content of the mobile application, together with some standards presented by the Mobile Accessibility Guidelines (W3C WAI 2021). In this way, it was weighted for evaluating and analyzing the four main principles: perceivable, operable, understandable, and robust (POUR).

2. Automatic Validation

It was selected a three automatic validation tools for accessibility that proved to be adequate to the context: WAVE – Web Accessibility Evaluation Tool, Access Monitor and SortSite Accessibility Checker and Validator.

3. Manual Analysis through TalkBack

For manual analysis, the authors chose TalkBack, a tool included in Android mobile devices that visually impaired users widely use. The scenario of a visually impaired user was simulated as close as possible to reality using the application with the help of the screen reader.

5. RESULTS

With the use of all the tools mentioned in the previous topic, it was possible to analyse the Hominere application and identify aspects that be unsuccessful in accessibility and define possible solutions to correct these aspects. Next, the results are presented according to POUR principles.

5.1 First principle – Perceivable

The principle of Perceivable states that content should be perceivable to all users (W3C WAI 2018), so the authors highlighted the following aspects:

5.1.1 Small Screen Size - Criterion 1.1 (WCAG 2.0)

The application analysis showed that the application does not guarantee the provision of acceptable sizes on some buttons in terms of their proportions and the spacing around them. Considering that the minimum size a button should have been 44px - 44px, several screens of the application are found buttons with smaller dimensions. In the most severe case, the button to return to the previous page with a proportion of 8px -14px (Figure 2).

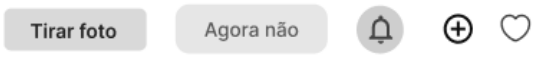

Figure 2. Examples of buttons that do not reach 44px in height

5.1.2 Contrast - Criterion 1.4.3 (WCAG 2.1)

The authors tested the contrast between the elements that make up the app using several tools, such as Stark[4]. Considering that the minimum desired contrast value is 4.5:1 for standard text, it was concluded that the Hominere app presents contrast problems in the chosen color palette (Figure 3).

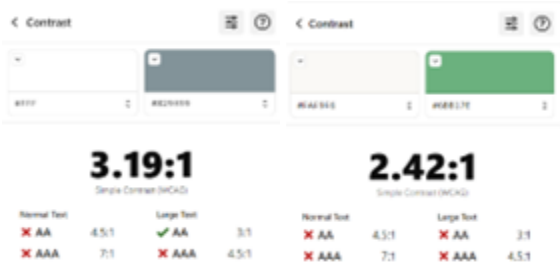

Figure 3. Example of lack of contrast between colors

5.1.3 Visual Presentation - Criterion 1.4.8 (WCAG 2.1)

Regarding the visual presentation of the information, the authors found flaws that do not allow the user to customize the background and foreground colors. In some screens, the minimum line spacing required is not met (this point will also be addressed in criterion 1.4.12).

5.1.4 Text Spacing - Criterion 1.4.12 (WCAG 2.1)

The authors found that the Hominere app does not meet several success criteria regarding text spacing. The line spacing, which ideally would be equivalent to 1.5 of the font size, takes on a value of zero (0). The app

also fails to meet the spacing between characters or words, which ideally would be 0.12 and 0.16 of the font size, respectively.

5.2 Second Principle – Operable

According to WCAG 2.1, the operability principle is related to the navigation and interface being operational, so the authors assessed the following aspect: Placing buttons where they are easy to access - Criterion 3.5 in WCAG 2.0. In some situations, the buttons are only positioned for easy access by right-handed users. In addition, some buttons occupy a very high position on the page and without margins, thus compromising their touch since not all devices will present favorable conditions for their display, as is the case of cell phones with the front camera positioned in the upper right corner.

5.3 Third Principle - Understandable

The understandable principle holds that the user must understand the content presented (W3C WAI 2018). Following this definition, the authors found the following aspects:

5.3.1 Consistent Layout/Consistent Navigation - Criterion 4.2 (WCAG 2.0) and Criterion 3.2.3 (WCAG 2.1)

Regarding the consistency of layouts, the authors observed that on the forum page, there is no consistency concerning the other pages, giving the impression that this section does not belong to the platform. This is due to the scarcity of the color palette, which is generally very present and the difference in the background color and aesthetic components characteristic of the Hominere app (Figure 4).

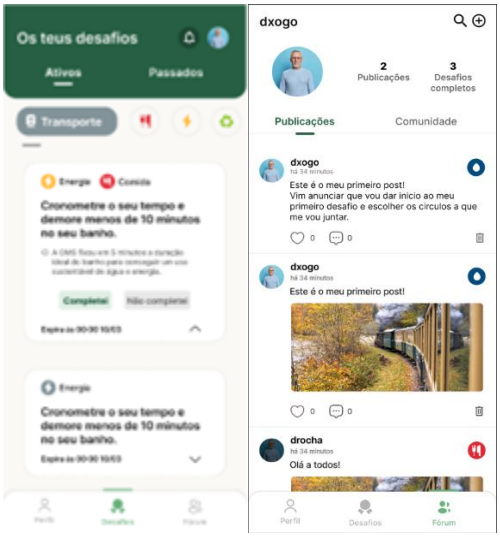

Figure 4. Challenge and forum pages

5.3.2 Error Identification - Criterion 3.3.1 (WCAG 2.1)

This criterion states that if an input error is automatically detected, the error element should be identified and described to the user in text. The authors have detected some problems with this criterion. On the registration page, users may enter invalid values, e.g., fake or incomplete cell phone numbers and e-mails that have not been correctly validated (e.g., aaa@aaa) without being informed of this. In this sense, false accounts can be created very quickly, which may not only impair the use of the application but also complicate accessibility for people with motor disabilities who may be mistaken in their credentials.

5.3.3 Positioning Essential Page Elements before the Page Scroll - Criterion 4.3 (WCAG 2.0)

Regarding the strategic positioning of essential page elements before the page scroll, the authors found that on the registration pages, the progress bar has an element that is at the top, and this is not the most relevant concerning the element that is next (question and options for setting the user profile and its forward button).

5.3.4 Provide a Clear Indication that Elements are Actionable - Criterion 4.4 (WCAG 2.0)

Another aspect at fault in the design is related to touchable elements. The app generally includes a box with rounded edges, a dark green background, and text or icons that are buttons. However, it is possible to see that there are other elements of quite similar structures, but they are not touchable. Furthermore, the aesthetics of the transport, food, energy, and recycle buttons (in a set) differ from the presented aesthetics of the symbols present within each publication, which could create difficulties concerning understanding and association.

5.4 Fourth Principle - Robust

Finally, the robustness principle translates that the content should be robust enough to be interpreted by various agents (W3C WAI 2018). In this respect, the authors found no inconsistencies.

5.5 Other Results

With the use of automated tools, it was possible to find other relevant aspects regarding accessibility and obtain results that meet the problems previously found in the guidelines.

5.5.1 Access Monitor Plus

The authors used the Access Monitor Plus tool for the automatic evaluation of the most relevant pages, and the scores (0-10 points) obtained are shown in Table 1.

Table 1. Scores obtained with the Access Monitor Plus tool

Page	Classification
Challenges	6,9
Profile	6,9
Forum	6,7
Notifications	6,3
Personal information	7,1

The authors still found some common errors among the pages regarding color contrast, as mentioned in the manual analysis through the guidelines. In this evaluation, several errors were found in the CSS file (e.g., with null alts) that do not meet the WCAG 2.1. This point strongly fails in the accessibility of the app since the alternative descriptive text to images decreases possible misinterpretations and improves the user experience.

5.5.2 WAVE – Web Accessibility Evaluation Tools

With the WAVE extension, the authors evaluated the developed project regarding the structure and organization of the code and visual accessibility with a focus on the contrast of the colors used. The page that reported more accessibility problems was the Forum, with one (1) error, three (3) alerts, forty-seven (47) contrast errors and a total of twenty-four (24) features without alternative text (Figure 5).

Using this tool, the authors found that the forum search bar does not have a corresponding label, which configures as an error, and that the color palette used by the Hominere app is not adequate, something that the authors had already concluded before.

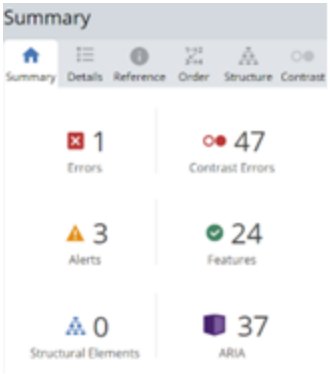

Figure 5. Results obtained on the Forum page using the WAVE extension

5.5.3 Accessibility Checker - PowerMapper

In general, the application did not present many problems when evaluated by the PowerMapper tool (Figure 6), presenting only two grave errors: in search - the application does not respect the Google, Bing and Yahoo guidelines, and in standards - there are validation flaws at the W3C HTML/XHTML level. However, it should be noted that since it is a Single Page Application (SPA), this type of tool cannot evaluate the entire application extension and only evaluates its homepage.

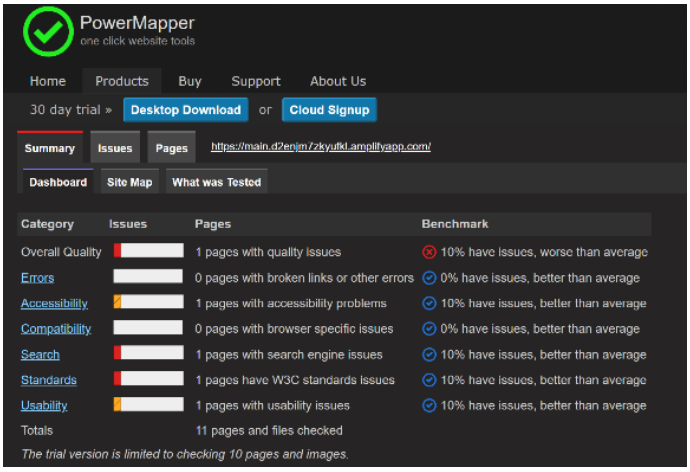

Figure 6. Overview of the PowerMapper evaluation results

5.5.4 TalkBack

To finish the results acquisition stage, the authors used the tool provided by Android mobile devices - TalkBack, to verify accessibility in a scenario where the user presents visual limitations. The evaluation process showed the need to improve several aspects since, in several situations, the user was confused about his progress and could not complete the tasks assigned to him without the help of a second person. Thus, the results revealed that using the Hominere app by people who need screen readers is practically impossible.

6. POSSIBLE SOLUTIONS

As it was possible to observe from the elaborated analysis, the authors identified several points that need to be improved to allow this app to have greater accessibility and a better user experience.

One of the possible strategic solutions to adopt would be to increase the button proportions. They generally present smaller sizes than is advisable, so increase their dimensions to 44px at least is mandatory. In buttons with essential functions, adding a background is also an option so that the element gains more prominence and a larger touch area. Finally, it is necessary to improve the positioning of some buttons and consider implementing them to allow left-handed people to use the application without any inconvenience since buttons are positioned for better access with the right hand.

The palette would need a revamp, as most of the colors failed the contrast test, and a definition to ensure consistency because several shades of green do not differ much from each other. In the Stark tool, it is possible to see some color suggestions within the same color spectrum, which would solve this problem.

Regarding the visual presentation of information, the application could include in the settings page an area dedicated to accessibility, where the user can customize the background and foreground colors. In addition, this accessibility area could include other options, namely text spacing, giving the user freedom to adjust it to their needs, as well as a night mode option.

The application also presented flaws regarding the comprehension principle. The authors used the design guidelines to assess the consistency of layouts/navigation to follow logic and coherence. For example, the main buttons should all have the same color scheme, or the background should have a constant color instead of varying between shades of white and beige. Besides helping the application's consistency, these guides would also solve the problem regarding touchable elements since all these elements would be designed in the same way or with similar logic (depending on the cases).

Regarding positioning the essential elements of the page before the scroll, the suggestion is to invert the order of the elements. The progress bar would be presented at the end of the page, ensuring that the relevant information appears first. As for positioning elements too close to the edges, it is only necessary to set fixed margin values. This way, there is no failure to display information because it is in a position that coincides with the physical elements of the device.

Regarding the null alternative texts, it is necessary to provide descriptive texts to the images that appear throughout the application so that all users can capture them in the best way and have the best experience that the Hominere app can give. This way, add the alt="[description]" field in the code referring to the images so that users have access to this information. In the case of the forum, it would be interesting to allow each user to define their descriptive text for the image post they have published. This is especially important for blind users, as they can hear the description through tools such as TalkBack and understand what images are on the pages and what they represent. However, images are not the only ones that need extra care for reading by the screen reader; buttons and text must be configured to read correctly.

Regarding search engines, the application has several flaws that violate Google Search, Bing Search and Yahoo Search guidelines, which can negatively affect its positioning in search results. One of the leading solutions to improve search engine accessibility would be offering users an HTML site map with links pointing to the critical parts of the site. Links embedded in menus, lists and similar elements are not accessible to search engines unless they are in the site map.

7. CONCLUSION

This study has shown that the selected accessibility strategy evaluation, combining manual evaluation of WCAG and using a mobile screen reader with automated evaluation through specific tools, is effective and appropriated and can be replicated in the accessibility evaluation of other mobile apps.

The mobile application Hominere presents accessibility problems beyond visualization and aesthetics, necessitating correctly structuring the code that composes it. Accessibility elements should be placed in all necessary parts to make it possible for a user with limitations to enjoy the platform without discomfort, which now is not possible, even using tools such as screen readers. However, without restructuring the color palette and the proportions of some elements, achieving a satisfactory result will not be possible either.

Among the study limitations, the authors can mention the time constraints, which did not allow testing the application with people with different types of disabilities. At the moment, the suggested improvements are being made. In the next stage, the application is expected to be tested with end users, including people with some disability/disability.

In conclusion, incorporating accessibility assessment into the development process of this application will allow the development authors to correct the shortcomings identified and create an accessible product for the most significant number of people. This study reinforces the importance of learning and applying accessibility guidelines in platform/mobile application development, which is crucial to create inclusive and accessible digital products that meet legal requirements and provide a better experience for all users. Nonetheless, evaluating and ensuring digital accessibility remains a significant challenge, and more research is needed to develop effective evaluation strategies. The authors believe that to associate a protocol of evaluation by users is the key to a more complete strategy, and that it will be this field of research that they will investigate in the future and take this study to a higher level.

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REFERENCES

Ballantyne et al., 2018. Study of accessibility guidelines of mobile applications. *Proceedings of the 17th international conference on mobile and ubiquitous multimedia*, pp. 305-315.

Cao, S. and Loiacono, E., 2022. Perceptions of web accessibility guidelines by student website and app developers. *Behaviour & Information Technology*, Vol. 41, No. 12, pp. 2616-2634. https://doi.org/10.1080/0144929X.2021.1940278

Cooper, M., Kirkpatrick. A. and O Connor, J. 2016. *Understanding WCAG 2.0: A guide to understanding and implementing Web Content Accessibility Guidelines 2.0.* https://www.w3.org/TR/2016/NOTE-UNDERSTANDING-WCAG20-20161007/

Dias, J. et al., 2022. Automated Evaluation Tools for Web and Mobile Accessibility: A Systematic Literature Review. In et al. Innovations in Bio-Inspired Computing and Applications. IBICA 2021. *Lecture Notes in Networks and Systems*, vol 419. Springer, Cham. https://doi.org/10.1007/978-3-030-96299-9_43

Ismailova, R. and Inal, Y., 2018. Comparison of Online Accessibility Evaluation Tools: An Analysis of Tool Effectiveness. *IEEE Access*, vol. 10, pp. 58233-58239. https://doi.org/10.1109/ACCESS.2022.3179375

Kalbag, L., 2017. *Accessibility for Everyone*. A Book Apart: New York, New York. ISBN: 978-1-937557-62-1

Kearney-Volpe, C. and Hurst, A., 2021. Accessible web development: Opportunities to improve the education and practice of web development with a screen reader. *ACM Transactions on Accessible Computing (TACCESS)*, Vol. 14, No. 2, pp. 1-32.

Nilsson, E., 2018. *Accessibility Evaluation of a Mobile Application UsingWCAG 2.0 - An Evaluation of the CREDENTIAL Project's.* Karlstad University. https://www.divaportal.org/smash/get/diva2:1241573/FULLTEXT02.pdf

Oliveira, R. et al., 2021. Accessibility Solutions for Visually Impaired Persons: A Digital Platform Conceptualization. In *Handbook of Research on Multidisciplinary Approaches to Entrepreneurship, Innovation, and ICTs* (pp. 331-348). IGI Global.

Rutter, R. et al., 2007. *Web accessibility: Web standards and regulatory compliance*. Apress.

Silva Neto, N. G. et al., 2021. Accessibility on mobile devices: an analysis from the perspective of human computer Interaction research in Brazil. *Brazilian Journal of Development*, Vol. 7, No. 4, pp. 34137-34150.

Slatin, J. and Rush, S., 2002. *Maximum Acessibility: Making you Web Site More Usable for Everyone*. Boston: Addison-Wesley.

Tymoshchuk, O. et al., 2021. Accessibility and microcopy remote testing of mobile applications: The case of the CeNTER platform. In *2021 16th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-6). IEEE.

Vieritz, H., Schilberg, D. and Jeschke, S., 2016. Early accessibility evaluation in web application development. *Engineering Education 4.0: Excellent Teaching and Learning in Engineering Sciences*, pp. 685-692.

W3C WAI, 2018. *Web Content Accessibility Guidelines (WCAG) 2.1*. Available at https://www.w3.org/TR/WCAG21/ (Accessed: 05 April 2023)

W3C WAI, 2021. *Mobile Accessibility at W3C*. Available at https://www.w3.org/WAI/standards-guidelines/mobile/ (Accessed: 05 April 2023)