Mobile Application Developed According to Accessibility Design Guidelines

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***Abstract*—Despite the existing accessibility technologies, mobile applications are not being developed accordingly or are not even minimally using these resources. People with disabilities end up having difficulty or even are unable to use applications that in principle would serve as something to make everyone's life easier, becoming a serious problem that deserves attention. For this purpose, an iOS application was developed correctly addressing the implementation of tools for accessibility to all users. This paper shows the development process of an iOS application (Palpite Olímpico) following two accessibility guidelines with the aim of promoting inclusion of blind people and users with low vision and/or visual processing disorders.**

Keywords-mobile applications; iOS; accessibility; guidelines.

I. INTRODUCTION

Mobile devices have become part of people's daily lives and applications are being developed with the intention of promoting a better quality of life for their users. According to the Enders Analysis Institute [1], while the number of users grows exponentially, so does the number of people with difficulties who also use these technologies to access information and facilitate communication. However, the development of accessible applications does not keep pace with the improvement of devices' technology, becoming inaccessible to people with disabilities. Kane et al. [2] say that, despite the accessibility tools available in them, there is still a lack of adequacy of technologies focused on people with disabilities, making it difficult to use these devices and consequently their applications.

Hammel and Magasi [3] emphasize that the accessibility of mobile communication does not mean simply keeping users connected with other people; it also means offering them more security and autonomy, aiming to be socially independent and an integral part of society.

According to a report by the United Nations [4], it was registered that there are more than 1 billion people living with some type of disability in the world. The World Health Organization (WHO) [5] estimates that 39 million are affected by blindness and that 246 million suffer of moderate or severe loss of vision. Given this information, focusing on developing accessibility resources for these users becomes relevant, allowing them to use technology in their daily life.

With this motivation in mind, this paper shows the development of a mobile application for iOS according to accessibility design guidelines, aiming to meet the needs of these people who have visual disabilities. With more efficient interactions, it should bring them autonomy and make them independent on third parties for their use.

Palpite Olímpico is a mobile application developed for the 2020 Olympics, to allow to guess the matches of each game in the competition. This application presents a calendar containing all games matches, so the user would search for the match of his favorite sport and category and guess which country would win the selected match. According to the correct answers, the user would accumulate points and rise in the ranking among other users.

This paper outline is as follows. Section II describes the accessibility guidelines to help the development of accessible mobile applications. Section III shows the methodology used in the presented project and the results are described in Section IV. In Section V, we describe some preliminary user tests, followed by the conclusions in Section VI.

II. MOBILE ACCESSIBILITY AND DESIGN GUIDELINES

Accessibility of mobile devices refers to the ability to interact properly with the operating system of the devices (Android, iOS, Windows Phone, among others). To ensure that visually impaired people interact properly with mobile devices, there are a number of accessibility tools available in the operating systems of these devices, such as a screen reader, magnifier and contrast control [6].

There are some accessibility standards available in order to guide the development of applications accessible to users with special needs.

A. Web Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) was developed by the W3C (World Wide Web Consortium - the main standardization organization on the World Wide Web) [7]. It aims to provide guidance to create accessible content in a standardized way for the web for people with special needs. It does not specifically address mobile applications, but the principles and success criteria outlined in WCAG is relevant to mobile apps [8].

WCAG consists of four principles [7]:

- Perceptible: Information and interface components must be presented to users so that they can perceive them. The idea is to provide text information for non-text content, such as images and buttons;
- Operable: Interface components and navigation should allow users to use them without difficulty. For example, providing keyboard access to all functionalities to include users that do not use mouse for interaction;
- Understandable: The information and the interface must be understood by all users. For example, all text should be readable and understandable and the interaction should be intuitive and predictable;

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- Robust: Content needs to be robust enough to be concisely interpreted by a variety of user tools, including assistive technologies.

For each principle, there are a number of secondary recommendations that indicate how to address the primary ones. In total, 61 standards make up the normative part of the WCAG and three levels of compliance can be achieved if they are met [7]:

- Level A: It is the minimum level of criteria met in general accessibility barriers, but does not guarantee a highly accessible application;
- Level AA: Meeting the requirements at this level already guarantees a very accessible application for most users and use of most technologies;
- Level AAA: It is the most rigorous criterion to be reached, as it has already passed through level A and AA. At this moment, it is necessary to refine the technologies for very specific situations of accessibility, unique cases and unfortunately few applications apply criteria at level AAA.

B. Human Interface Guideline

Developed by Apple [9], the Human Interface Guideline (HIG) is a guideline that offers a series of recommendations, in order to improve the user experience through more intuitive, didactic and consistent interfaces. It was created to enrich the development of applications for all Apple mobile devices.

In the HIG, there is the Accessibility section, which addresses the four main categories of disabilities: visual impairment, hearing loss, physical and motor disabilities, literacy and learning disabilities [9].

The first categorized disability, visual impairment, comprises blindness, color-blindness, all forms of vision loss and situations that make viewing the screen uncomfortable or difficult to read. For these users, Apple offers VoiceOver, a tool that translates all information present in the interface in speech; color inversion to change how content is displayed; font size configuration that allows users to set the size of the text; screen zoom that enlarges the screen and a feature that uses the device's camera as a magnifying glass.

The second category of disability is hearing loss. In those cases, there are alternatives to aural interaction, such as closed captions, visual and haptic notifications and typing for Siri.

People with physical and motor disabilities fall into the third category, which impacts the ability to hold or manipulate devices. These people are provided with features, such as Switch Control integrating devices adaptable to the iPhone, iPad, Mac and Apple TV. Users may use Siri to control the devices and applications using their own voice and also Assistive Touch that facilitates the interaction through standard gestures.

The fourth category falls under the issue of literacy and learning disabilities, comprising difficulty in speaking and reading, managing complex things and staying focused. In order to reduce cognitive load and support these users, the operating systems provides features such as Speak Screen - the system reads a text for the user; Typing Feedback - while typing, user receives feedback as well as speak text corrections and word suggestions; and Safari Reader - isolating text without distractions, such as advertisements.

III. METHODOLOGY

For the development of this project, the Challenge Based Learning (CBL) methodology was used. This methodology helps finding solutions to real problems, in a fully collaborative way, regardless of the area and situation of the problem, it consists of three different interconnected phases and each one presents unique activities to raise questions and information that would gather essential data for the future solution of a problem [9]. All these phases are documented and reflected at each stage of the process (Figure 1): Engage, Investigate and Act. CBL is a circular process, that is, it does not have a middle and an end; all research can come and go during its phases [10].

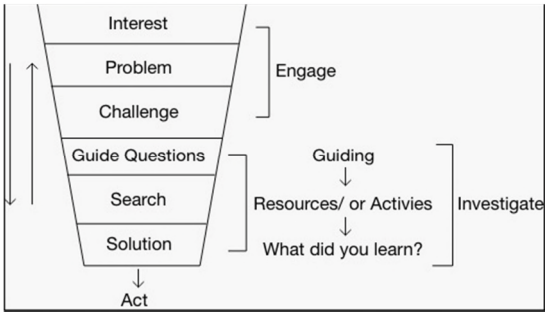

Figure 1. Challenge Based Learning Processes.

The first phase is Engage and, at this moment, it is necessary to choose a large area of activity known as Big Idea. In the project described in this paper, the area was "Accessibility". Next, a more specific problem is chosen - an essential question which would be the focus of research and from this problem, it should follow to a concrete challenge. As the objective of this work, the challenge was "To develop a mobile application that could meet most of the disabilities and needs of users with accessibility features".

In the second phase called Investigate, based on the challenge, a series of questions were raised that would help understanding the problem and would be fundamental to find an optimal solution to it. They are known as Guiding Questions and some of them were: "*What guidelines to study to use as a basis for the development of this application?*", "*What accessibility resources can we focus on in the study and development that will bring greater value to users*?", "*How to correctly apply these resources and technologies?*". After researching and answering all of the questions, it was possible to understand more about both guidelines of Human Interface Guideline and WCAG.

Finally, the Act phase is precisely the implementation of the solution defined as a result of the investigation phase. The solution consisted of the development of Palpite Olímpico, an iOS application for guessing the matches of each game in the Olympics. It is important to highlight that the focus of this challenge was not the development of the

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mobile app, but the creation of an accessible application. For this purpose, the proposed solution should support Voice Over, Dynamic Type and Color technologies Contrast Checker.

After developing the solution, some preliminary tests were carried out with two representatives of the target audience: one with Cataracts disease and another with color blindness.

IV. RESULTS

This paper presents the beta version of Palpite Olímpico, an accessible iOS application, developed in a period of just two weeks, following each phase of the CBL methodology. The proposal was to develop an accessible and inclusive application according to accessibility guidelines (WCAG and Apple's HIG).

For this purpose, it was decided to implement Voice Over to allow autonomous navigation by blind people; Dynamic Type for the ones with low vision to have better readability in all elements of the application; and Color Contrast for people who are color blind and have low vision to have a better contrast of the colors in the application.

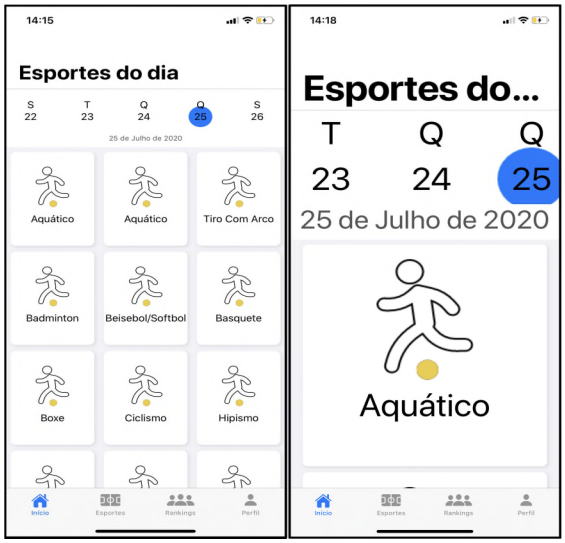
It is important to emphasize that, although all of these features are offered by Apple's devices natively in their operating system, only few apps support them. For them to work correctly, it is necessary to implement them programmatically and adapt the applications accordingly.

The Dynamic Type tool was implemented throughout the application and when enabled, the font size of the text in the app must adapt to the size and weight specified in the device settings. As previously said, to work correctly in mobile applications, this feature must be manually implemented. With the necessary adaptations for the app, it should accommodate larger fonts dynamically, keeping the text legible and clear when enlarged and also making it bold.

Figure 2 (a) and (b) shows the support of Dynamic Type. In Figure 2(a), it is possible to see Palpite Olímpico's home screen without the feature enabled, with a calendar at the top showing five days a week and below a collection of sports with three sports per row. Figure 2(b) presents the home screen with the Dynamic Type enabled at its maximum size. It can be noted that the distribution of the elements change, the calendar now shows only three days, and the sports categories are arranged in only one column instead of three. It was all developed to provide better readability of the information on the screen by people with visual impairment or loss of vision.

Regarding the colors chosen for the app, contrasting colors were selected in relation to the background, to better identify the elements. It was also provided a feature for users with color blindness to choose the color palette to be applied according to their type of color blindness.

To confirm the effectiveness of the color contrast, WCAG's Color Contrast Checker tool was used to calculate the contrast ratio between foreground and background elements. It also evaluates the font color of a text or icon and the color of the background element and Palpite Olímpico obtained the AAA level classification. It reached the most rigorous criterion and with the most refinement possible, in all the colors of the system, guaranteeing an ideal accessibility, for color blind people and people with low vision.



(a) (b)

Figure 2. Palpite Olimpico screens: a) Home screen of the application without Dynamic Type; b) Home screen with Dynamic Type enabled.

The Voice Over feature was also implemented, helping blind users to navigate the entire application. It allows navigability through touch providing an audio description to guide the interaction. The user may swipe left or right to navigate and double-click to select items. Every time Voice Over is activated, a black rectangle appears around the element the user interacts with, that also may help users with low vision to navigate.

All audio narrated by Voice Over was edited by a Pronunciation Editor, allowing to create phonetics corresponding to the subject, providing tips on how to interact with the selected element, describing images, texts and button actions. It is important to create good labels and image descriptions in order to provide a better experience to blind users while navigating through a mobile application.

V. PRELIMINARY TESTS

To prove the efficiency of the accessibility tools developed in this project, two usability tests were carried out. The first test performed was with Bruno Nogueira, a 56 years old man with Cataract disease. Cataracts are eye lesions that make the lens opaque and leave the vision blurred, as if there was a mist before the eyes. It causes difficulties in activities such as reading, driving, sewing and even walking due to vision difficulty [11]. Bruno stated that he often stops using his cell phone because he can not see almost anything on the screen.

The test consisted of three steps. The first step was asking him to try to use the application Palpite Olímpico with the standard font size of the operating system. The user could not see anything, just a blurry screen and he was unable to distinguish what was really being shown. In the

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second step, the largest font size that comes standard in the system was activated. At this moment, the user started to distinguish some texts and icons, but he was not sure what was written or what the icons represented. In the third step, Dynamic Type was applied in its largest font size and the user stated that he could read everything and also distinguish the icons, as he was using glasses and a magnifying glass. For this user, the color tone was also beneficial because his disease also affected the brightness of the colors. Bruno also stated that "it would be incredible if every application could place fonts of this size, because I often need to use the cell phones, but there is no one near me to help and I end up being dependent on others".

The second usability test was carried out with Guilherme Caiola, a 24 years old young man with the condition of color blindness which is a vision disorder that interferes with color perception. This condition can be of three types and, in this case, he has deuteranopia, which is the absence or decrease in green cones sensitive to medium-length waves. So, instead of green colors, he sees shades of brown [12]. In this test, Guilherme should browse the application Palpite Olímpico with the standard colors and it was clear that it was possible for him to see and understand everything. Guilherme pointed out the contrast between the texts and the images, thus confirming that the use of color contrast at the AAA level actually worked. He stated that "it would be very interesting if all applications were designed with the contrast of colors, because it is impossible for me to read and understand the interface otherwise".

V. CONCLUSIONS

The design of applications with accessibility does not keep pace with technological innovations. It may cause people with disabilities to end up once again suffering from the lack of efficiency of the applications, which in principle should bring them autonomy.

This work presents the development process of an iOS mobile application (Palpite Olímpico) concerning some accessibility features such as: Voice Over for blind people to be able to browse autonomously; Dynamic Type for users with low vision making font size adapt to the size set in the device; and the Color Contrast Checker at AAA level, to provide better experience for color blind and low vision users, enabling the correct choice of colors.

While developing this app, it was noticed that it is a really difficult and thorough process so that all accessibility features and tools have an efficiency and safety during their use. It is often necessary to make adjustments to the layout and even the navigation flow.

One of the biggest lessons while working in this project was learned during the usability test. Before this stage, the thought was that people who needed accessibility resources were people who had already been born with some type of disease or were used to their conditions. In fact, accessibility must be a concern for everyone, because at any moment a disability or illness can arise, and these resources may be needed.

All mobile developers should be aware of the importance to focus on accessibility because it also includes those who do not have difficulties, but at one time or another they may need it. It is a totally social cause that deserves attention.

As next steps, it is expected to carry out tests with a larger sample of users, to effectively prove the relevance of using accessibility guidelines in the design of mobile applications. It is also necessary to test the efficiency of the Voice Over feature and prove that it allows navigation autonomously and without error for this type of user.

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