Evaluation of Tablet PC Application Interfaces with Low Vision Users: Focusing on Usability

Cínthia Costa Kulpa and Fernando Gonçalves Amaral

Federal University of Rio Grande do Sul, Porto Alegre, Brazil
cinthia.kulpa@gmail.com, amaral@producao.ufrgs.br

Abstract. This article described the results of a qualitative research by analyzing a focus group, on the accessibility of Tablet PC application interfaces regarding the digital inclusion of low vision users, which brought evidence of the need for studies on how those users view, recognize and interpret the information presented by this new technology, with the purpose of making it possible to provide better usability of those interfaces. For such, it presents the themes involved such as: mobile technologies, low vision disability and accessibility, leading on to discussions on the digital inclusion of those users.

Keywords: Tablet PC, low vision, accessibility, usability.

1 Introduction

The significant evolution of mobile technologies has broadened the options of resources and strategies for digital inclusion, since they allow for interaction to take place anytime, anywhere, free of time and space limitations, as they are connected to wireless networks and integrate mobility, communication and processing power [1].

This way results in flexible groupings to occur, where age and location become more relevant, with people interacting according to their interests, needs and curiosity; producing a growing number of users of virtual environments through mobile technologies and the broadening of the diversity in their profiles.

The Tablet Personal Computer (TPC), a computer in the shape of an electronic clipboard with virtual keyboard and touchscreen is the technology most widely implemented in teaching institutions worldwide among the currently available mobile technologies [2] and [3]. At present, the TPC is deemed the best form of presenting information through text, image, video and audio applications [2]. Moreover, it offers users applications that allow for real time interactivity by navigating in the virtual environment, make notes, research terms, interact with other users, among other possibilities.

However, as the amount of applications developed for TPC grows, there is also increasing use of such applications by different user profiles, bringing to evidence difficulties in performing tasks, that leads to loss of data, reduced productivity and even full rejection of this new technology by those users, since those applications do not include in their interfaces accessibility for different users that considers their

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personal traits, behavior, needs, discourse, as well as disabilities and limitations brought on by the physical environment or technological barriers [4].

Although accessibility is increasingly present in virtual environments, it is not yet explored by applications for TPC, in comparison with existing computer systems, since there are few applications for this technology, and also because the development of such applications involves significant periods of time and investment. In some cases of applications for TPC, the use of the Universal Design is seen, but "Universal Design based projects do not ensure compliance and accessibility to all persons in the same manner due to the broad diversity of disabled and non-disabled persons, and due to the situations in which those persons find themselves" [5].

The demographic census of 2010 [6], shows that 24% of the population have disabilities with degrees of severity investigated. Among the disabilities pointed out, low vision comprises 18.3% of the Brazilian population, that is, 35 million Brazilians are diagnosed as having low vision disability. Those data point towards the pressing need for research and studies on the development of the new applications for TPC aimed at providing accessibility for these users, and indicating the likelihood of them being TPC users if some particularities or adjustments were to be observed [5].

From the information presented above, it can be noticed that there is a need to investigate the use of applications developed for TPC by persons with Low Vision disability, taking into consideration better usability and ensuring accessibility for those users

2 Mobile Technologies

For an interface to serve a person with low vision to provide accessibility, it is of no use that developers makes use only of the World Wide Web guidelines that are available and always updated to build interfaces; they must learn what possibilities those users have, their traits, expectations and needs. Otherwise, that interface will always be bound by the Universal Design recommendations, which seeks to include the highest number of users through generalized actions. In that case of differences not being considered, it creates obstacles for users with low vision, since they will have to adapt to the interfaces that are imposed, limiting the use of their functional vision and setting the threshold of possibilities at the lower level.

Moreover, a technological revolution has been taking place in the world, affecting, among other areas, education, not only with the advent of the first TPC (2010), but also the expansion and massification of that technology. The need to produce efforts that would result in knowledge and information to assist the development of applications for TPC with adequate accessibility and usability for persons with low vision has become inevitable and conclusive.

The market currently offers several types of mobile technologies, more commonly known as mobile devices aimed at corporate and general consumers [7]. The TPC is classified as a computer, as well as being called a personal mobile device, which is integrated to a large interactive screen, is in the shape of a clipboard and has access to the wireless virtual environment. It features a touchscreen that, by touching with the

finger tips or using a specially designed pen for it, activates its functionalities and is the main entry device to browse around this platform. It is considered to be a new concept, that stands out with its capability of allowing users to write using a pen directly onto the screen.

The first TPC was created by Apple Inc. and was launched in 2010, called the iPad. Since then, several similar models have appeared, which goes to prove it has been accepted by the general public.

There are two operational systems for TPC: Android and iOS. The Android operational system was launched by Google through a partnership with companies from varied fields of activity and is defined as an Open Source platform for mobile devices that makes use of Java programming language and allows for developers to access the system application framework whenever they wish to build an Android application. The iOS is Apple's mobile operational system and is restricted to Apple devices only [8].

Some of the differences between the TPC and other technologies is that it makes it easy to access and display text and presentations, youngsters are prepared for this technology, it integrates trends, is increasingly affordable, there is software being designed that is suited for this technology and the device is adjusted to the profile of youngsters concerning technological cognition and Human-Computer Interaction.

3 Human Computer Interaction

The graphic interface is the visible part of the software to the users, through which they communicate with the system to perform tasks. Visual perception is attained when the users manage to "intuitively" handle the visual representation that is configured in the relation between what the developer wishes to inform and what the user perceives from that information [9].

Interface is not only the image that appears to the users, it is a set of interface entities that relate with the application or system entities and that results in the users not even noticing that they are interacting with the system [10]. Therefore, user interfaces cannot be thought of without considering the human being who will be using them and relating with the computer. To be able to understand how this effective communication takes place it is necessary to learn about the human-computer interaction.

Human-Computer Interaction (HCI) involves topics such as design, assessment and implementation of interactive computer systems focused on the use by people, besides being concerned with the main phenomena that involve this relation: human-computer [11]. These studies are concerned with producing systems with better usability, effectiveness, utility, security and that are more functional. This way, it can be stated that the term "systems" refers to the hardware, software and the entire computational environment, either through the use or affected by the use of this technology [12].

HCI encompasses a multidisciplinary view to assist in improving acceptability by analyzing different points of view and taking into account different human factors. Thus, this human-machine interaction relation is unique and individual, since each

user carries an exclusive experience according to their traits, expectations, life and culture [13].

The development of graphic interfaces must make use of knowledge related to HCI in order to project a graphic interface that will assure not only adequate functionality of the system, but its usability as well.

Usability refers to how fast users can learn how to use something, its efficiency, satisfaction, easy memorization and the level of propensity to mistakes [14]. It can be classified as a characteristic quality in the use of programs and applications by indicating an agreement between interface, user, task and environment [13].

And it is through usability aims that makes it possible to identify problems when using a graphic interface Those aims concern effectiveness, efficiency, security, utility, learning capability and memorization capability. In addition to those aims, there are the aims that result from user experience. Even so, they are not clearly measurable, since they indicate that an interface must be satisfactory, pleasant, fun, interesting, useful, motivational, esthetically appealing, creativity inducing, rewarding, emotionally adequate.

Recognizing and understanding the balance between the usability aims and those resulting from user experience becomes very important, with the types of aims established depending on who will be the users of the system being developed, in addition to their context of use, capabilities and objectives [11].

4 Low Vision

Low vision is defined as a severe loss of sight that cannot be corrected through clinical or surgical treatment or with conventional glasses; and it is related to the visual capacity a person has located between 20/40 and 20/200, after correction [5].

Such severe loss leads to an important hindrance of visual function, but it is not characterized as blindness. The hindrance that occurs may be related to the reduction of visual acuteness, adaptation to light or darkness and differentiating colors. However, this condition does not prevent the person from planning or performing tasks using their sight[15].

People with low vision are in an intermediate position between the reality of people who can see normally and total visually disabled people. Since they have limitations that make it impossible for them to perform certain functions, they are not treated as someone with normal sight. However, they are not considered to be blind, since they have a residual sight that allows them to perform some tasks perfectly well. This marginal condition leads to a social exclusion level that is much stronger than the exclusion of people who are blind or have normal sight [16].

The “Convention on the Rights of Persons with Disabilities”, adopted by the UN in 2006, came about to defend, promote and ensure conditions of life with dignity and emancipation of citizens of the world who have some form of disability. Among the principles of that convention, are included the person's independence, individual autonomy, full and effective participation and inclusion in society, respect for the difference, equal opportunities for men and women, and accessibility.

5 Accessibility

Accessibility in the virtual environment, for a person with low vision disability, goes far beyond the search for information, it is the possibility to include that person in society in general, since it eliminates communication barriers. And, according to the UN Convention for the rights of persons with disabilities, if there is no accessibility it means there is discrimination, condemnable under the moral and ethical view, and punishable in the form o law. This way, all States Parties undertake to promote inclusion on equal bases with other persons, as well as providing access to all existing opportunities to the population in general [6].

There are several guidelines to assist developers in the pursuit of accessibility in the virtual environments. Nevertheless, it can be observed that the vast majority of interfaces developed is aimed at users in general, and do not take into account those users who have some form of disability. Concerning the cutting edge technologies, such as TPC, there are no guidelines that include users with low vision disability, making accessibility difficult to this type of system by those users, and as a consequence, hindering their digital inclusion.

Digital inclusion involves overcoming several barriers that involves the development of solutions for the diversity of the human potential by making information and communication accessible, usable and useful for everyone. The solutions for those challenges must be built by and with the players involved [18]. Strategies and solutions must be outlined to make possible the construction of a digital society for everyone that promotes the full exercise of citizenship and educational inclusion based on the human rights.

6 Research Methodology

In order to gain an initial understanding of the interaction of low vision users with TPC and its application interfaces, in addition to identifying and analyzing likely usability problems in such interaction, a qualitative research with a focused group was chosen. Since this type or research is not representative regarding the stratified population, it was used to seek the generation of data to feed quantitative researches that will allow to perform a future triangulation of both results.

The 5 participants were chosen for having low vision disabilities regardless of each one's diagnosis and etiology, taking into account only the functional vision that would make it possible to handle and choose their actions on the TCP not requiring the support of assistive technologies.

In order that they all could interact among themselves at the same dialog level, it was established that the participants should be aged between 18 and 28 and inserted within the academic context. They were members of the Incluir Program at UFRGS, which supports actions that favor the inclusion of persons with disability in higher education. All the participants were familiar with the computer technologies:

A script was used that contained open questions presented by the moderator who carried out the interview. Initially, each participant was handed and read to a term of

free and clarified consent explaining the objective of the research and their participation rights. The script was created with questions that would lead the study to its closure naturally, as presented in Table 1 below:

Table 1. Questions Covered in the Interview

Type of Question	Question
Introductory	What is the diagnostic of your visual disability?
	Talk about your functional vision
Transitional	What do you think of the Tablet PC?
	Have you used a Tablet PC?
Directional	Please turn it on
	Which elements in the initial interface are perceived?
	Try to change the TPC configurations to be able to use it according to your profile
	Try to navigate in the Virtual Environment
Of Closure	Talk about the ease of use
	Did you feel secure using a Tablet PC?
	What were the difficulties perceived
Final	Would you like to complement with any impression?

The chosen location was a meeting room at UFRGS, with indirect lighting, with the participants positioned around a table. They were handed a TPC with the operational system Android 3.1 and a 10.1 inch screen with several applications in the initial interface (Fig. 1).

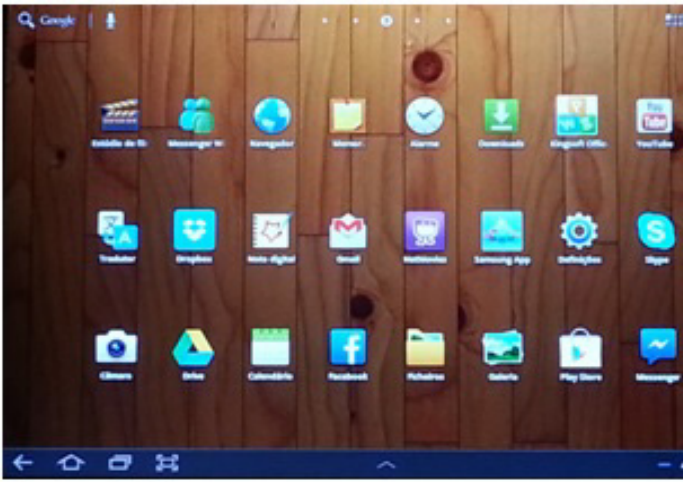

Fig. 1. Initial Interface with Applications

The interview was recorded on video and audio, with the information being later transcribed, analyzed and interpreted, as presented in the final considerations of this paper.

7 Research

It was first requested of the participants to talk about the diagnostic of their disability and how they classified their functional vision. All that information was relevant, despite all of them having complied with the research selection criteria, since it is the functional vision that determines the quality of sight and gives them autonomy in their actions. Furthermore, since sensitivity to light was one of the characteristics that could interfere in the interview results, it was possible to adjust the position in the environment of the participants who indicated this characteristic.

Of the five participants, three are sensitive to light, one has "poor functional vision" (quoted from the participant) which made many autonomous actions inviable. All five participants wanted to have a TPC, as they imagined it a being an alternative technology for reading and navigating in the virtual environment without the difficulties perceived in other devices. Only one participant had the opportunity of handling a TPC before this interview, but he added that the experience lasted only a few minutes.

They were asked to turn on the TPC. In the beginning, none of them managed to perform the action, not even together, without the intervention of the moderator. The on/off button is fitted to side of the product (Fig. 2) with the volume button next to it, both with the same texture and color of the product, and the on/off button must be pressed and held for a few seconds to be activated. The indication that it is turning on is provided by sound and moving image, but two participants pressed the volume button together with the on/off button, muting it and making it impossible for the participants to identify that is was on. Additionally, they did not perceive the moving image because it was too quick.

Fig. 2. Location of the On/Off Button

As to the colors and shapes of the application icons located on the initial interface, the color contrast was considered strong, but they could not understand the details in most of them or identify what was written below each one, since the font was too small. The camera icon was clearly identified, as was the Facebook icon (Fig. 3) that in addition to being located immediately on the interface, all five perceived the white, "f" over the blue background. The distance observed between the participants' eyes and the TPC interface was of 3cm to 10cm.

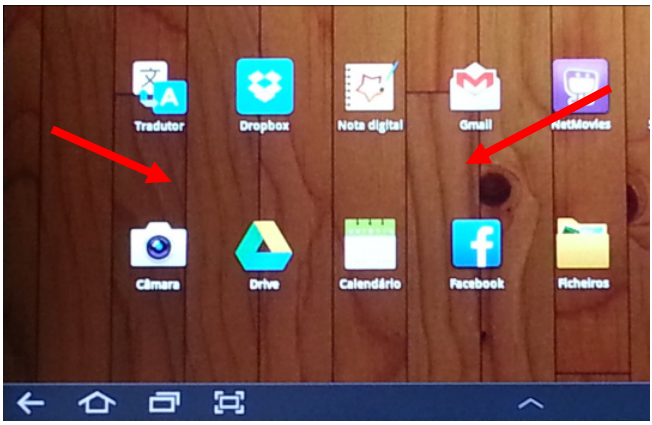

Fig. 3. Facebook Icon and Camera Icon

They noticed the lack of an expanded legend for the icons, since there it the name of the application just below them and activation is done by touching, not with a mouse. They all considered the interface, clean, organized and simple. They noticed that the icons with a ¼ of the screen in size were easier to understand and identify.

They were all asked to try to configure the TPC according to their profile from the "Definitions". Two of the participants asked where was the zoom for the initial screen to be able to better follow the navigation choices. The moderator told them that the system does not have its own initial zoom. For approximately five minutes they were all concentrated in finding the icons that would identify the "Definitions", and in the end the moderator indicated the location of the TPC definitions.

Once in the definitions screen (Fig. 4), they selected the "Accessibility" item because they wanted to adjust some tools. Once in the "Accessibility" screen, the participants questioned the meaning of the tools (Fig.5). They found the terms difficult to understand, and after being explained their meanings with the existing tutorial, the found that they were not the accessibility resources they were looking for, such as contrast change, zoom font size, etc.

The automatic screen rotation modified the position of the TPC interface several times due to the movement the participants made to better adapt the viewing of information, which led them to lose the point they were focusing on and having to start the action from the beginning. The moderator indicated the path to turn off the selection of that tool.

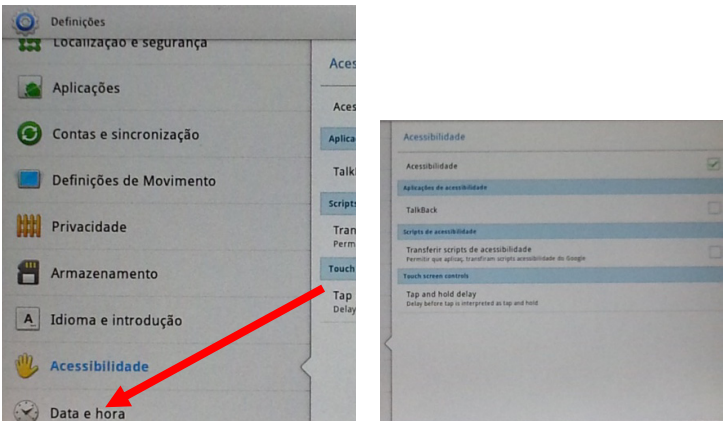

Fig. 4. Definitions of Configuration and Accessibility Tools

To navigate in the virtual environment, it was necessary to indicate the icon. In the initial interface, they did not find the zoom feature, it was only perceived once they had chosen a site th navigate. They considered the "new page tab" easy to understand and intuitive due to the contrast between the white fonts on the black background and the shape, but the size of the font prevented them from reading what was written. They were pleased with the contrasts, zoom and readability of the information on the sites.

As to the questions related to the closure of the interview, it was decide to place the statements in a table (Table 2) to related them with the usability goals referred to in this paper. Following the presentation of Table 2, the results and authors' considerations will be presented.

Table 2. Statements and Usability Goals

Statements	Action Stage
"this is difficult"	Interaction Intuitive
"it will be no use trying to use this kind of technology"	
"I found a button, pressed it and nothing happened"	
"oh, this button must be held and I think it turned on because it vibrated"	
*"application distribution is go**od**, clea**n**"*	Learning Capability and Memorization Capability
"I would need to know the icons beforehand to be able to memorize the shapes of these ones"	
***"The** contrast would help me more., but it can't **have too much contrast**"*	
"I can't identify what this is and have no idea of what it is"	
"can I click here?"	
"to expand do I have to go to configurations?"	

Table 2. (*continued*)

"where are the configurations?"	
"the contrast is good, but it is difficult to arrive here"	
"it does not give any security in choosing the action"	Effectiveness And Efficiency
"words of difficult understanding"	
"that is not the accessibility I wanted to find!"	
"translate this!"	
"the screen position change when I move the TCP is not good, because it undoes my mental image related to the path I was following"	Security And Protection Against Mistakes
"I need help to lock it"	
"the first time round it is difficult, but worse is to find out on my own"	Trust Autonomy
"how long would it take me to learn?"	
"some things here are accessible, but how do I get to these accessible things?"	
"it's a matter of lack of autonomy"	
"too intuitive"	
"it's too sensitive"	

8 Results

According to the statements given, it was possible to map the usability goals that could help with better navigation by considering each one of the problems perceived by that user.

The difficulties found to turn on the TPC occurred due to the formal oversimplification of the product components. It would be possible to improve this interaction by simply modifying one element in these components, such as texture, button color or shape, together with the automatic response to user action (in this case "press the button"). Interaction with users could be taken into account without interfering with the formal aspect of the product and its components. In this case, it resulted in frustration of and questioning by the user of his or her autonomy.

The initial interface proved to have optimistic learning and memorization qualities, since the participants appreciated the lay out of the elements and their contrasts. The possibility of using the zoom tool in this page could better help them to choose the applications, the application icons could have the option of increasing their size to make readability easier, or the legends below the icon could have larger sized fonts. Such improvement could reduce the search for the applications and increase the certain choices by these users.

The accessibility resources present in the TPC were seen as "lacking efficiency" and not at all "effective", since they did not perform what they were apparently

proposed to do, communication of their objectives did not have an accessible language, did not meet the expectations of the participants and caused disappointment. The lack of resources such as zoom, increase font and contrast in the item "accessibility", led to questioning about where those resources are actually located. They could be highlighted in the initial interface, thus ensuring a minimum navigation in the system with security, initiative and sureness of action. In this case, it was noticed that the insecurity caused by the uncertainty about the actions was present throughout the interview.

The participants finished the interview with a rather different idea of the TPC from the initial one. They all questioned the adaptation time they would require to gain a minimum interaction with the product. It was observed that there was a lack of autonomy in this interaction.

9 Conclusion

The objective of this research was to list the issues related to the digital inclusion or persons with low vision disability in the new technologies. The intention of gathering the data that would point to possible problems in this interaction was only attained through the effort and patience of the participants involved.

Considering the significant figure of 35 million persons with low vision who could be benefiting from cutting edge technologies, such as TPC, so that they may be included in the digital and educational media, it can be noticed that there is a need for more actions that would consider them within the scope of not only existing technologies, but also where new technologies are concerned.

With an understanding of how persons with low vision disabilities communicate with their surroundings, what their expectations are and the actual limitations imposed by the physical, digital, and especially social media, it is possible to intervene in favor of the quality of life of those persons through the use of the accessible competences and possibilities.

A proposal for the future is to further the studies on this interaction by composing researches that are representative of the population of users with this trait through individual interviews based on the usability tests and user experience.

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