Accessibility Guidelines for Virtual Environments

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Abstract. The technological advances resulting from the Digital Revolution have enabled the growth of virtual spaces, of the most varied types and for various purposes, facilitating access to information, as well as communication between people. However, a large number of people cannot enjoy these benefits because they face difficulties related to accessibility in these environments. In this scenario, the objective of this work is to present a conceptual framework, which contain a set of Web accessibility guidelines to allow a greater number of people to take advantage of the resources and facilities provided by virtual environments, regardless of their physical or functional limitations. In addition, it should be emphasized that the present research is not intended the presentation of a rigid guide or a step by step, but rather a suggested model, composed of recommendations that represent a compilation of different surveys and that intends to offer a direction to developers in creating Web environments with better accessibility.

Keywords: Accessibility guidelines · Virtual environments
Conceptual framework · Physical differences

1 Introduction

The great changes caused by the so-called Digital Revolution had an impact on society as a whole, affecting political and economic aspects as well as social and cultural aspects. According to [12], by January 2017, the number of existing sites exceeded 1.8 billion. However, if on the one hand, there is an increase in the number of virtual environments and people who benefit from them, on the other hand there are individuals who, due to physical or functional limitations, cannot access the content and information provided by those environments

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According to a World Report on Disability, released by [20] in 2011, more than 1 billion people in the world live with some type of disability; in addition, according to another report released by [20] in 2014, the number of older people should double, reaching 2 billion by 2050. These figures only corroborate the concern about creating Web spaces as inclusive as possible.

In the literature, it is possible to find different works with a focus on Web accessibility. However, research related to this topic usually deals with specific issues, which involve only one type of disability, or some accessibility recommendations for a particular type of environment. In this scenario, the objective of this work is to present a conceptual framework, which contain a set of Web accessibility guidelines to allow a greater number of people to take advantage of the resources and facilities provided by virtual environments, regardless of their physical or functional limitations. According to [22], by improving Web access and its resources, people with some type of limitation are allowed to participate more actively in society.

In order to elaborate the guidelines, this research used the following methodological steps: (i) diagnosis of the characteristics and elements that compose the virtual environments; (ii) selection of works related to Web accessibility, according to their relevance (main recommendations for users with different types of physical or functional limitation); (iii) selection of works related to the use of the user's natural interface; (iv) compilation of accessibility guidelines to support the creation of more accessible virtual environments.

2 Digital Accessibility

The concept of accessibility is very broad, and according to [5], involve physical-spatial factors such as distance, displacement and comfort, as well as political, social and cultural aspects.

Article 3th of [3] defines accessibility as "[…] possibility and scope for the safe and autonomous use of spaces, urban equipment, buildings, transportation, information and communication, including its systems and technologies, as well as other services and facilities open to the public, for public use or private for collective use, both in urban and rural areas, by persons with disabilities or with reduced mobility."

Therefore, according [5], the concept of accessibility involves the practice of social inclusion of citizens, because it is related to the possibility of their participation in society, so that there are conditions of equality. In this context, [11] defines the goal of accessibility as guaranteeing a better quality of life for people, and especially for people with disabilities, who face the greatest difficulties.

Regarding these difficulties, [13] states that functional weaknesses considered as characteristics of individuals with special needs can be divided into the following general categories:

- Visual impairment: people with reading difficulties of very small texts or of a particular color, or even may need visual information to be converted to oral or Braille speech;

- Hearing impairment: people who have difficulty hearing or recognizing audible signals as acoustic warning signs (beep);
- Movement impairment: people with difficulties that prevent them from using the keyboard or mouse;
- Cognitive impairments: people differences in perception or language impairments.

Regarding Web accessibility, it is necessary to highlight the contributions made by the World Wide Web Consortium (W3C), which is an international organization in which affiliated companies, full-time teams, independent organizations and public work together to develop standards for the Web. One of the contributions by the [21] was the creation of the Web Accessibility Initiative (WAI), which seeks to develop strategies, guidelines and resources that help make the Web accessible to people. According to [22], Web accessibility makes it possible for people with disabilities, as well as those who may have had some loss of ability (such as older people) to perceive, understand, navigate, interact and even contribute with the Web.

In addition, [21] has developed the Web Content Accessibility Guidelines (WCAG). This set of guidelines provides recommendations that seek to standardize the accessibility of Web content. In doing so, by following these guidelines, Web content becomes accessible to a wider range of people with disabilities, including blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movements, speech deficiencies, photosensitivity, and individuals with combinations of these characteristics, besides users in general.

Also related to [21] contributions, this consortium has the Web Accessibility Working Group (Web Accessibility WG), which was created in March 2012 and meets periodically to plan actions to be carried out in Brazil. The WG Brazil highlights that people with disabilities are the biggest beneficiaries of a more accessible Web, because a virtual environment with low accessibility can harm these users or even prevent their access. On the other hand, good accessibility allows people with disabilities to enjoy all the information and services available on the web.

Also with regard to Web accessibility, it is possible to cite the Modelo de Acessibilidade em Governo Eletrônico (eMAG) or Accessibility Model in Electronic Government, created by the Brazilian federal government. The [7] helps professionals in the development, alteration and/or adaptation of pages, Websites and portals, in order to do them accessible to a larger number of individuals, thus increasing digital inclusion and, consequently, social inclusion. For their conception, experts contributed, taking into account the latest research related to the area of Web accessibility, in addition to the recommendations of [19].

Moreover, one point that deserves to cite is the relationship between usability and accessibility. According to the [21], usability and user experience enable to design products to be effective, efficient, and satisfying. Additionally, according to [8], usability is the "[…] extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". [14] define usability as being the speed with which users can learn to use something, their efficiency in using it, as well as how much they can remember and enjoy using it.

[18] present the following usability principles: Error prevention and handling; Consistency; Feedback; Control; Efficiency and efficacy; Easy learning; Flexibility; Visibility; Compatibility; Easy Memorization; Prioritization of Functionality and Information; Equitable Use; Affordance; Help; Shortcuts; Low Physical Effort; Restrictions; Reversal of Actions; Subjective Satisfaction; and Security.

The concept of usability can be related to accessibility, according to [21], since basic accessibility is a prerequisite for usability. In this way, accessibility can be considered a subset of usability. Therefore, it is probable that, satisfying some usability principles, some characteristics related to accessibility are met. In addition, a virtual environment with better usability will possibly help your users navigate with greater satisfaction and want to return to that Web page.

3 Conceptual Model for Supporting the Creation of Virtual Environments with Focus on Accessibility

This work is part of a study by the HCI group of the State University of Paraná, which develops two complementary studies, one focusing on natural interfaces and the principles of usability, interactivity and communicability for a specific type of environment, the Virtual Museums, and the other focusing on the accessibility aspects of Virtual Environments in general. Thus, to reach the objective of this work, which is to propose accessibility guidelines through a conceptual framework, first will be presented the concepts related to framework and conceptual framework.

[17], in his master's thesis, defines a framework as "a generic project in a domain that can be adapted to specific applications, serving as a template for the construction of applications". Thus, according to [2], a framework has as main idea, to enable the use of a set of common resources, allowing its reuse in the development of new applications.

Consequently, it is possible to facilitate one of the frequent situations faced by system developers, which is the need to use similar resources for the development of new programs. In view of this, [17] emphasizes that the reuse provided by a framework becomes a necessary condition for achieving a productivity gain, for software development.

With respect to the conceptual framework, [9] defines as being a network of interconnected concepts that, because they are together, provide a comprehensive understanding of one or more phenomena. The author also clarifies that, instead of offering a theoretical explanation, as well as the quantitative models, a conceptual framework provides understanding, and it can be developed and constructed through a process of qualitative analysis. For [15] the objective of a conceptual framework is to "[…] provide a class diagram that can be used as a basis for modeling application domain classes."

3.1 Conceptual Model

To create the conceptual framework, researches were carried out that involved several types of virtual environments, as well as the main difficulties encountered by its users. From this, and based on the main factors of the design of interactive systems proposed

by [1] and the contributions of [16], a conceptual model was proposed, which served as support for the creation of the final conceptual framework.

As can be seen in Fig. 1, the conceptual model presents, for virtual environments, three main elements in its structure: (i) People; (ii) Components; and (iii) Activities. It should be noted that each of these elements may have subelements, which may also have their unfolding, and so on. The segmentations from the first level seek to reflect the specificities of each type of virtual environment. For example, a Virtual museum, can present as Functions of element People: administrator, curator, specialist and visitor; a real estate site, in turn, can present for this same element, the functions of administrator, multimedia expert and visitors; therefore, subelements may vary, but they will come from a common element.

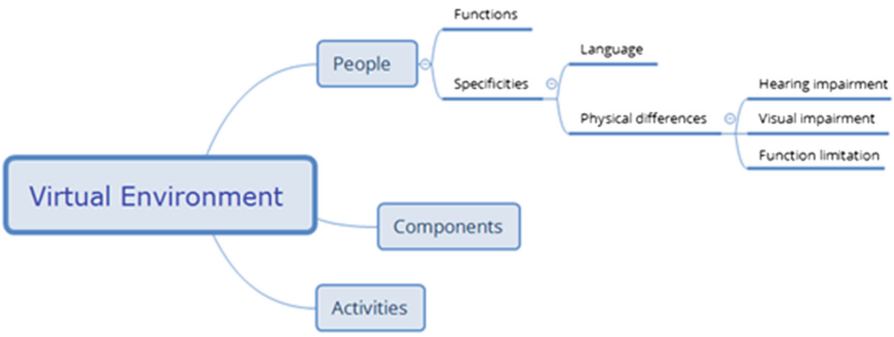

Fig. 1. Conceptual model to support the creation of the conceptual framework.

Below, each element and its sub-elements will be explained in more detail.

People

The People element is divided into Functions, which represent the types of people that will interact with the virtual environment; and Specificities, which has the Language in which the environment will be created, as well as the physical and psychological differences of the various users that can access the virtual space.

Functions

Types of users that will interact with the virtual environment, from different forms. Two examples will be presented below, in order to present possible functions related to two different types of environments: a virtual museum and a distance learning system. It is hoped, with these examples, to show that, because of there are different types of virtual spaces, the definition of roles will depend on the needs and objectives of each environment.

In a virtual museum, it is possible there are the functions of administrator, curator, computer graphics specialist and visitor. Thus, the administrator would be responsible for determining what information will be available in the museum, by selecting and requesting content that can be created and/or adapted by a curator and/or computer graphics expert; curator, according to [6], is anyone who participates in a curatorial

process, which includes collection, research, safeguarding (museological conservation and documentation) and communication (exhibition and education); a computer graphics expert, in turn, is a generic definition for the person in charge of tasks involving the use of technology to make the content, determined by a curator, for later display in the virtual museum; finally, a visitor is any individual who accesses the virtual museum in search of information, knowledge and learning.

Another example of defining functions may be in relation to the creation of a distance learning system. In this system, the functions could be module coordinator, mentoring coordinator, tutor, support and student. In this way, the module coordinator would be responsible for the organization and administration of the course, being a professional in the teaching area of the course; as for the mentoring coordinator, would be a professional in the area of education that manages the way tutors work; the tutor, in turn, would be a user with good knowledge in technologies, in order to propose ways of interaction of its content by other media; as for the support, would be a professional with technical functions, related to the technology used, not needing to have knowledge about the subject of the course; finally, the student, who is the user that will access the system and will be responsible for their own learning.

Specificities

The Specificities element is divided into Language, Physical differences (Hearing Impairments, Visual Impairments, Functional Limitations) and Physical Differences.

With respect to virtual environments, it is necessary to emphasize that their access can be realized from any city, country or continent. Consequently, people of different native languages can visit these virtual environments, making the concern with idiom an important issue in their creation.

As for the physical differences between the various visitors of a virtual environment, the [21] says that the Web must be accessible to provide equal opportunities to people with diverse abilities, which range from users without physical limitations to those who may have some kind of disability, such as hearing, visual or physical. These deficiencies can affect a person from birth or be acquired and/or developed during their lifetime, in the event of accidents, illnesses and even the advancing age.

Furthermore, it is necessary to consider possible psychological differences between the different visitors, which includes different cognitive capacities. For example, according to the [21], an elderly user may have reduced cognitive abilities, affecting their short-term memory and ability to concentrate, and consequently impairing their Web browsing.

Components

In the Components element, there are subelements that can be part of a virtual environment. Thus, as in the case of the Functions subelement, the composition of the Components element will depend on the purpose of the virtual environment created.

Typically, a virtual environment may have components such as:

- Text: presentation of textual information, available to the visitor, which can be related to the details of an item, how space is used, data about the authors, among others.

- Video: material that can be used to explain certain content present in the environment; may contain subtitles or be also available in other languages, such as sign language of deaf communities.
- Audio: audio is a more dynamic and effective way of transmitting information. It can be an explanatory audio, about a certain item present in the environment in order to improve the accessibility of the virtual environment.
- Image: can be captured images (photo) or digitally generated images.
- Object: three-dimensional objects, related to the environment theme, which can be available to the user's touch for manipulation and observation.
- External Link: used to access information from other pages, inside or outside the virtual environment, such as news or additional information related to the subject or to some element of the environment
- Navigation Map: virtual environment plan, serving as reference so that the visitor can be located inside the museum and better understand how the site is organized.

It should be noted that for creating a virtual environment, it is not necessary for all components presented to be part of the space created or, still, other components may be present. However, by using a greater number of elements, the environment tends to be more diverse, attractive, interactive and accessible. In addition, combining the natural user interface with these components, it is possible to further facilitate the accessibility to the environment content, since, according to [10], this type of interface focuses on the natural abilities of being human such as touch, vision, voice, movement, and cognitive functions such as expression, perception, and recall. Access to an image (when available) can use, for example, touch commands in order to zoom in it on and manipulate it; also, searching for certain information may use voice commands, assisting users with limitations that difficult their use of mouse and/or keyboard.

Activities

The Activities element is related to what each of the functions will perform during their interactions with the virtual environment. For a better understanding, the possible activities related to the two examples already discussed will be presented: virtual museum and distance learning system.

In a virtual museum, an administrator may be responsible for the inclusion, alteration and exclusion activities of a curator and a computer graphics expert, in addition to being able to approve/refuse and include/exclude content made available by a curator; a curator is responsible for organizing and validating content related to the theme of the virtual museum; as for the computer graphics specialist, is responsible for tasks that involve the use of computational resources, working in partnership with the curator, in order to diversify the content made available by a virtual museum; the visitor, in turn, is anyone who can visit the virtual museum, searching and accessing a specific object, visiting the virtual rooms and/or accessing details about an object.

In the case of a distance education system, there is the coordinator of the module, responsible for the organization, coordination and administration of the course, approving the didactic material and the contents to be taught during a given course; in relation to the mentoring coordinator, is responsible for the pedagogical tools, as well as for the coordination of the work of the tutors; as for the tutor, it is responsible for the interaction between the student and the teaching platform, becoming very important in

the success and motivation of the distant students; in relation to a support professional, is responsible for maintenance, improvements and other issues related to the technical part of the system; finally, a student, has as possible activities, access to the system and material made available, as well as resolution and sending of tasks, as well as other.

Therefore, each of the elements of the conceptual model presented will depend directly on the objectives, contents, user types, technical needs and other peculiar factors of the virtual environment to be developed. However, in all cases, one should try, to the maximum, to facilitate accessibility to the various types of users who will have access to the system. In Sect. 3.2, below, guidelines will be presented that can assist in improving accessibility for virtual environments.

3.2 Accessibility Guidelines

In this section, some accessibility guidelines will be presented, based on the proposed conceptual model. These guidelines are intended to contribute improve accessibility in virtual environments, especially for users with some type of disability, physical or cognitive limitation, as well as their activities in the use of virtual environments.

Establishing a relation with the conceptual model, considering that the People present some specificities as to their physical or cultural conditions, guidelines will be presented, which are intrinsically linked to the Components that the environment may have (contents, images, alternative media, among others) to that the Activities can be developed by all People, regardless of their culture or physical differences.

Regarding the criteria used to select the accessibility recommendations in virtual environments, were used researches based on the four principles of accessibility that constitute the [21]: perceivable, operable, understandable and robust. In addition, some of the recommendations presented come from research that was based on works by different scholars on accessibility, as well as recommendations that integrate the [7] or that are in line with some of the usability principles already presented.

Table 1 is related to improved accessibility for blind or vision impaired users, referred to in the table by the letter “B”, as well as improved accessibility to deaf or hearing impaired users, referred to in the table by the letter “D”. For the elaboration of the table, were used the researches carried out by [4], whose objective was to evaluate the accessibility of deaf people in Websites, taking into account the view of different authors. Also for the creation of Table 1, the work of [11] which evaluated the accessibility of the visually impaired in virtual practice communities, was used as a basis, showing a series of relevant aspects in the creation of these virtual environments, some of them very important for creating virtual environments in general.

It is possible to notice, in Table 1, that the attention given in the creation of the different aspects presented, can help certain types of users, which are represented by different letters. Therefore, these aspects cover different elements and subelements elucidated by the conceptual model presented in the previous section.

Thus, by following the guidelines associated with these aspects, it is possible to favor the improvement of accessibility of users with different types of disabilities. Therefore, it is verified that the improvement of accessibility in virtual environments can result from the exploration of different elements of the proposed conceptual model.

Table 1. Accessibility recommendations for blind or vision impaired users and for deaf or hearing impaired users.

Aspects		Guidelines	Benefited users
Content Creation	Content Language	Page title should be simple and clear	B
		Headings and labels should describe the topic or the topic purpose	
		Position the labels in order to make clear what elements they refer to	
	Language	Indicate the language to the user, both in the interface and in the encoding	B, D
	Visual Representation	Separate foreground from background, for easy navigation via keyboard	B
Communication Mediation	Mediation of Interpreters	Provide a language interpreter for sign language mediation	D
User Navigation	Alternate Text for Links, Images and Elements	Provide textual alternative to link, image or any type of non-textual elements by means of the 'alt' attribute	B
		Provide a simple description of the images, in order to facilitate the understanding of the users	B, D
	Keyboard Use	Provide all functionality and shortcuts through the keyboard to make it easy to use screen readers	
		Provide Help About the Virtual Environment	
	Links destination	Indicate, clearly and succinctly, where the links are pointing	
Technologies and Alternatives for Time-Based Media	Technologies Used in Videos	For visually impaired people with blindness, all possible information must be passed through audio	B
		Ensure understanding rate of the deaf for visual detection of hand movements and facial expressions	D
		The delay of the image should be less than 1.2 s to enable the video feature of signal language	
	Media Time	Provide the user with control over the executions of the media, such as: start, stop, resume and others	B
		Provide video description of audio information and allow the user to control the speed of content that "moves"	D

Source: Adapted from [4] and [11].

Table 2, in turn, contains recommendations from studies by [18]. These studies involved researches based on the work of different authors, resulting in a table that relate some of the usability principles already presented, with recommendations that may help both usability and accessibility in the development of digital information environments for the elderly.

It is important to highlight that, although Table 2 emphasizes the benefits provided to elderly users, who tend to present greater physical and cognitive difficulties, the presented guidelines can also help the accessibility of people with less experience of using virtual environments, as well as experienced users who do not have any cognitive and/or physical loss.

Table 2. Essential usability and accessibility recommendations for digital information environments for the elderly.

Principles	Guidelines	Authors
Error prevention and handling	Provide clear messages to the user about an error of his own in the execute of a certain task or even a system error	Nielsen (2002); Zaphiris et al. (2007)
Consistency	Layout, navigation and lettering/terminology should be simple, clear and consistent	Zaphiris et al. (2007)
	Exhibit information (messages, icons, labels, etc.) and interaction objects (edit field, command button, etc.), repeated on different pages of the site, in consistent positions and shapes	Zaphiris et al. (2007); Sales and Cybis (2009)
Feedback	Provide confirmation for tasks performed by the user	Zaphiris et al. (2007)
Control	Do not use pull-down menus and Promote enough time to read the information	Zaphiris et al. (2007); Sales and Cybis (2009)
	Do not provide options that require double-clicking	Zaphiris et al. (2007).
	Avoid the automatic scrolling feature unless can be simple way disable it	Sales and Cybis (2009)
	"Click here" and "read more" links are highly accessible by this audience, as its direct them to actions they may not be able to visualize	Vechiato (2007); Vechiato and Vidotti (2008)
Easy Learning	Use color distinction for visited and unvisited links	Nielsen (2002); Zaphiris et al. (2007)
	The icons should be simple and meaningful	Zaphiris et al. (2007); Sales e Cybis (2009)

(*continued*)

Table 2. (*continued*)

Principles	Guidelines	Authors
Visibility	Use uppercase and lowercase letters; avoid the use of long phrases with uppercase letters	Zaphiris et al. (2007); Sales and Cybis (2009); Echt (2002).
	Provide descriptions (in full, in captions, etc.) of abbreviations or acronyms and highlight them when they occur on their first occurrence on each page	Sales e Cybis (2009)
Prioritization of Functionality and Information	Highlight for the most important information	Zaphiris et al. (2007); Sales and Cybis (2009)
	Information should be concentrated in the center of the page	Zaphiris et al. (2007)
Affordance	Provide clues to users about where they are located on a Web page at the time of access	Zaphiris et al. (2007); Sales and Cybis (2009)
Low Physical Effort	Facilitate interaction between the user and the page, preventing repetitive actions	Sales and Cybis (2009)

Source: Adapted from [18].

3.3 Application of the Conceptual Framework

In order to verify the possible benefits to accessibility in virtual environments, some of the recommendations proposed in this research were applied in the development of a virtual museum. This museum aims to present the history of the municipality of Bandeirantes, located in the northern part of the state of Paraná (region known as Pioneer North) in Brazil.

For the creation of this virtual museum, some recommendations related to the creation of content were followed, such as use clear and simple titles to identify a page, position the labels appropriately, indicate the language of the page to the users, both in the interface and in the encoding. Some recommendations were also followed regarding user navigation, providing alternative texts for images and elements, as well as trying to clearly indicate where the available links point to.

Also, some usability principles, and their respective recommendations, were opportune for the created environment. In this way, a layout was created for a simple and clear navigation, aiming to result in a consistent museum. Also, were avoided options that require double click, as well as automatic scrolling of text and, on the other hand, links of the type “click here” and “read more” were placed in prominence, trying to meet the principle of control. In relation to links, were distinguished the visited ones of those not yet visited. In addition, acronyms used were described, in addition to prioritizing information in the center of the pages and providing tasks with low physical effort.

4 Conclusion

It is hoped that with this research, it will be possible to contribute to the elaboration of more accessible virtual environments, through the conceptual framework presented, directing, in this way, the development most varied types of virtual spaces, such as institutional, advertising, studies, art, culture, e-commerce, etc. It is also hoped that this study may also serve as a reference or help for future research which has the idea of improving the framework proposed by this work or even creating a new model.

For this reason, the present study should not be interpreted as a rigid or step-by-step guide, but rather as a suggested model, composed of recommendations that represent a compilation of different researches and are intended to serve as a basis, or, at least, offer a direction on developers to create more accessible virtual environments.

In addition, proposing a conceptual framework with a focus on accessibility, can collaborate not only for more virtual environments to be developed, but can also serve as a support for a greater variety of users to access and enjoy these virtual spaces, the which tend to grow, both in terms of quantity and content.

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