ACCESSIBILITY AS AN ELEMENT OF SOCIAL AND DIGITAL INCLUSION THROUGH THE DEVELOPMENT OF VIRTUAL LEARNING ENVIRONMENTS IN THE USE OF ICT IN SOCIETY

Ranniéry Mazzilly Silva de Souza

University of the State of Amazonas,
Manaus, Amazonas – Brasil
ranniery34@globo.com

Viviane Gomes da Silva

Federal Institute of Education, Science and Technology of Amazonas,
Manaus, Amazonas – Brasil
prof.viviane@gmail.com

This paper defines the term accessibility in its various aspects and discusses its importance as an element of social and digital inclusion, as well as the use of ICT (Information and Communication Technologies) in society. It describes the Web Accessibility features, reporting standards and accessibility recommendations, such as the World Wide Web Consortium (W3C) and International Organization for Standardization (ISO) and specifications. It also lists the specifications regarding accessibility software. It presents the types of web accessibility evaluations, differentiating automatic from manual tools and finally approaches accessibility to learning environments. In addition, it deals with the impact of all these analyses on the development of e-learning. One thus concludes that there are many guidelines and recommendations for accessibility in the development of web applications, and which can be used in e-learning environments. However, developers are not aware of all the technical details required to implement these recommendations. Despite the number of research studies on the topic of accessibility in virtual learning environments, there is still much to develop. In addition, more research should be conducted in order to validate accessibility evaluation strategies in learning environments, which should significantly contribute to results that allow for the broad inclusion of new users in learning platforms

Keywords: accessibility, social and digital inclusion, virtual learning environments, e-learning, ICT.

1 INTRODUCTION

The changes in the scientific, technological, cultural, social and educational world occurred in contemporary society were instrumental in bringing the benefits of technology to education needs. In the midst of these changes the information and communication technologies (ICT) have become essential resources to promote the improvement of educational systems. The diversity of "new learners" users of these new technologies prompted the e-learning to remarkable advances. Given this context, it is observed that the conjunction of accessibility and e-learning provides great benefits to users, contributing mainly to the digital and social inclusion. In addition, the combined efforts of this union may reduce the barriers faced in the area of the professional qualification of people, allowing for access to learning environments and their development.

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2 ACCESSIBILITY

According to [10]**,** a general definition of accessibility means “the quality of being accessible; an easy approach in dealing or obtaining, a condition of access to information, documentation and communication services by the disabled person”. Therefore, accessibility can be understood as the possibility of autonomous access to the social and physical environment, be it public or collective.

The Universal Declaration of Human Rights, specifically Article XIX, states that every human being has the right to receive and impart information and ideas [36]**.**

However, in reality, many groups in society have seen the cessation of their rights. This is the case, for example, of people with disabilities, who struggle daily to be integrated in society in a dignified manner. Yet, unfortunately, they are frustrated in most of these fights due to the existing obstacles maintained by society. According to World Health Organization**,** in the WHO Report to the 58th World Health Assembly, 10% of the world's population (approximately 650 million people) live with a disability and about 80% of these individuals are located in developing countries.

For the United Nations for Culture, Science and Education Organization [35] , the development of the accessibility of information and communication technologies (ICT) magnifies the inclusion of people with disabilities through knowledge, which is divided into four pillars: 1) Freedom of expression and information to all, 2) Open access to sources of knowledge, 3) Teaching quality, and 4) Respect for differences and human diversity.

There are multiple dimensions of accessibility. ISO defines six of these dimensions:

a) Architectural Accessibility (access to any public or urban transportation and environment);

b) Accessibility of Communication (speech, or ability to receive messages through the media or communication systems);

c) Methodological Accessibility (removing the barriers in methods and technologies related to varied study issues - research, work and social life, for example);

d) Instrumental Accessibility (no barriers in the instruments and tools of study, work and leisure);

e) Programmatic Accessibility (no invisible barriers included in public policies, rules, regulations);

f) Attitudinal Accessibility (there should be no prejudice, discrimination, stigma and stereotypes).

The limitations of people with disabilities can become barriers in their access to information systems. "Developing accessibility features would be a concrete way to neutralize the barriers caused by disabilities and enter that individual in rich environments for learning, provided by the culture" [13].

According to the declaration of accessibility of the GNU project [15], it is estimated that 85% of software applications and websites do not meet the standards and accessibility guidelines. Accessibility in software is important for disabled people, as well as those who are not. Recent studies show that most of the features and concepts used to develop software for people with disabilities are also used by many other people due to their easy interaction and increased efficiency of use. Consequently, when the software is designed to be accessible to people with disabilities, it becomes more usable for all other users [2], [9].

Given this context, it is observed that the conjunction of accessibility and e-learning provides great benefits to users, contributing mainly to the digital and social inclusion of people with disabilities. In addition, the combined efforts of this union may reduce the barriers faced in the area of the professional qualification of people with disabilities, allowing for access to learning environments and their development.

3 WEB ACCESSIBILITY

Accessibility is a theme related to usability. International Organization for Standardization (ISO) defines usability as a function of efficiency, effectiveness and satisfaction with which users can reach their goals in specific environments, when using a particular product or service. Accessibility focuses on application features that support universal access by any class of users and technology [32]. Literature presents accessibility in a broad meaning: that is, the ability of an application to support any users by identifying, retrieving, and navigating its contents [33]. In the case of web sites, accessibility focuses on properties of the markup code that make page contents “readable” through technologies which assist impaired users.

Web accessibility is translated into the fact that people with disabilities can use the Web. More specifically, it means that people with disabilities can understand, navigate, interact and contribute to the web. Web Accessibility brings other benefits, including the involvement of elderly people, whose skills have decreased over time [16]. Developing strategies, recommendations and resources to make the Web accessible to users with special needs is part of this accessibility-of-use context [17].

According to [21] the accessibility on the Web specifically relates to the web component, which is a set of pages written in HTML and interconnected by hypertext link. [24] state that there is an urgent concern for user accessibility during the interface design of web applications because, when designing software, one should consider that it will be used by people with different needs and characteristics.

3.1 Recommendations and Accessibility Standards

There are, currently, several documents relating to the recommendations, guidelines and accessibility standards for software. At an international level, several governments, universities and industries have developed or are developing their own techniques (eg, guides and checklists) for accessibility in software. In addition, some organizations are developing their own standards, recommendations and accessibility guidelines.

3.1.1 Recommendations for Web Content Accessibility - WCAG 2.0

Web Content Accessibility Guidelines 2.0 (WCAG) recommendations have been and are presently being developed by a group of representatives from industry, government, organizations and interested non-profit institutions in several countries. The official name of the group that created these recommendations is the Web Content Accessibility Guidelines Working Group (WCAG WG), which is part of the World Wide Web Consortium (W3C). This resulted in the Web Accessibility Initiative (WAI) established in 1997 [31].

The WCAG 2.0 is a set of recommendations with the aim of making Web content accessible to people with disabilities. These recommendations also facilitate the use of Web content for the elderly, whose capabilities are subjected to constant change due to the ageing process. It also facilitates use for general users. The WCAG 2.0 recommendations are organized in various levels of approach, which include principles, recommendations, success criteria, a set of techniques and common failures. These are documented with examples, links to resources and a source code. Figure 1 illustrates an overview of WCAG 2.0 [39].

Principles	Guidelines	Level A	Level AA	Level AAA
1. Perceivable	1.1 Text Alternatives	1.1.1		
	1.2 Time-based Media	1.2.1 – 1.2.3	1.2.4 – 1.2.5	1.2.6 – 1.2.9
	1.3 Adaptable	1.3.1 – 1.3.3		
	1.4 Distinguishable	1.4.1 – 1.4.2	1.4.3 – 1.4.5	1.4.6 – 1.4.9
2. Operable	2.1 Keyboard Accessible	2.1.1 – 2.1.2		2.1.3
	2.2 Enough Time	2.2.1 – 2.2.2		2.2.3 – 2.2.5
	2.3 Seizures	2.3.1		2.3.2
	2.4 Navigable	2.4.1 – 2.4.4	2.4.5 – 2.4.7	2.4.8 – 2.4.10
3. Understandable	3.1 Readable	3.1.1	3.1.2	3.1.3 – 3.1.6
	3.2 Predictable	3.2.1 – 3.2.2	3.2.3 – 3.2.4	3.2.5
	3.3 Input Assistance	3.3.1 – 3.3.2	3.3.3 – 3.3.4	3.3.5 – 3.3.6
4. Robust	4.1 Compatible	4.1.1 – 4.1.2		

Figure 1: Overview of the WCAG 2.0. [39]

3.1.2 Nordic Recommendations for the Accessible Computer

Nordic Guidelines for Computer Accessibility is a Nordic cooperation focusing on disability, which was organized under the Nordic Council of Ministers, the governments of Denmark, Finland, Iceland, Norway and Sweden. This orientation describes a set of functions linked to the accessibility of a personal computer system and the like. The recommendations also serve as a guide for ICT strategists, developers and standardization groups [34].

According to [34], the recommendations were developed as a common basis for the Nordic countries of Europe. The publication is divided into two parts: Part I, which describes what is meant by accessibility in information technology and communication, states the importance of including accessibility requirements in procurement, standardization and the ICT development process. Part II, which presents a set of functional requirements, addresses the need for the accessibility of personal computer systems operated by the end user.

3.1.3 ISO Accessibility Software Standard

The ISO guidance on accessibility software ISO 9241-171 - Ergonomics of human-system interaction –, is a standard designed for software developers and provides

orientation concerning software design in order to achieve the highest possible level of accessibility. ISO 9241-171 is a comprehensive technical standard, prepared by independent experts of international standards, and includes all persons with disabilities and all aspects of the software. It contains norms which specify many of the statements, establishes priority on two levels ("Required" and "Recommended") and presents a checklist designed to help test the results [18].

3.1.4 Accessibility Software Guides

There are many guides with orientations on how different aspects should be considered to increase and / or improve the accessibility of software. Among these documents are specific guides for some projects created by universities, companies, organizations or experts, for example: Adobe, Apple, Fujitsu and Oracle, among others. In their portals they provide accessibility to voluntary product templates, VPATs (Voluntary Product Accessibility Template), which are documents containing the necessary requirements for a product that complies with Section 508 (addendum to the American Rehabilitation Act of 1998, which requires that federal agencies use information and digital technology that is accessible to people with special needs).

4 EVALUATION OF WEB ACCESSIBILITY

In Human-Computer Interaction (HCI), the evaluation of interfaces is "the process of systematic data collection, which is responsible for letting us know how a particular user or group of users makes use of a product for a given task in a certain type of environment " [29]. Some of the objectives of this evaluation were to assess the quality of an interface design, to identify possible problems of interaction, to create an interface to compare project alternatives, to investigate how the interface affects the user's work and to verify compliance to standards and heuristics [28]. The assessment checks whether a user interface can use a product and derive enjoyment from it [29].

The evaluation of web accessibility aims to identify the barriers of access to sites and to communicate these problems so that they can be corrected [12]. In order to carry out a Web accessibility evaluation, the execution of a set of activities is recommended [1]. Such activities have specific goals and make use of software and hardware resources to support the assessment. The accessibility evaluation begins in

website development and continues to occur throughout its lifetime, thus monitoring and ensuring accessibility over time.

One of the simplest ways to carry out the accessibility of a web application is by using automatic accessibility evaluation tools. These tools are aimed at the evaluation process in accordance with a set of accessibility standards, such as the accessibility guidelines developed by the WAI (WCAG).

4.1 Automatic Evaluation of Web Accessibility

The existence of an automatic assessment provides a means to comply with laws, standards and guidelines and constitutes a factor which is directly related to the success of its use and implementation [3]. The following can be cited as automatic accessibility evaluation tools:

- The Eval Access: evaluates compliance with the WCAG 1.0. Available at: http://sipt07.si.ehu.es/evalaccess2/.
- The Hera: evaluates compliance with the WCAG 1.0. Available at: http://www.sidar.org/hera/index.php.pt.
- The DaSilva: evaluates compliance with WCAG 1.0 accessibility and the e-government model adopted in Brazil (E-MAG1). Available at: http://www.dasilva.org.br/.
- The Access Monitor is an automatic validator that checks the application of accessibility guidelines in the HTML contents of a website. Available at: http://www.acessibilidade.gov.pt/accessmonitor/.
- The API WAVE: shows the original web page with embedded icons and indicators, which reveal the accessibility of that page. It also accepts pages by URL, file upload, or by source code. Available at: http://wave.webaim.org.

It is important to highlight that automatic assessment tools are unable to assess the full compliance with certain standards and guidelines, such as the WCAG, owing to the subjectivity of certain checkpoints (considering the WCAG 1.0) and success criteria (considering the WCAG 2.0) presented in some of the guidelines [20].

The automated tools assess the compliance of websites according to simple rules of accessibility, without checking the semantics of accessibility metadata. For example, automatic tools are able to assess whether an image has alternative text content for one's presentation; yet, they are unable to identify whether this alternative text content is indeed relevant as a description for that image [4].

Above all, these self-assessment tools analyze the HTML code of web pages which are dynamically generated on the application server, using languages such as Active Server Pages (ASP), JavaServer Pages (JSP) and PHP - Hypertext Preprocessor. As a result, it then becomes difficult to report the exact cause of the detected

accessibility barrier. These tools also check the static HTML content on a page, without considering the possibility of a dynamic DOM structure, which is the case for Web 2.0 applications. Thus, these self-assessment tools are unable to consider any functionality implemented on the client-side of a web application [14]. Pointing out the problems related with the syntax of pages does not guarantee that a page without syntax problems is easy to use and is accessible. For example, an image can present an equivalent text description that neither clearly describes it, nor is it syntactically correct. Consequently, the description used does not contribute to the understanding of the image, thus making it inaccessible.

4.2 Evaluation of Manual Web Accessibility

Considering this limitation in the automatic accessibility evaluation tools, the WAI presents some orientations for the evaluation of accessibility and compliance with their web page guidelines. Of these, the following are highlighted:

- Preliminary evaluation: a review of pages that combines the use of automated evaluation tools and the manual analysis of certain accessibility criteria. This technique is insufficient when determining whether a page is available or not; however, it can report the most obvious accessibility barriers by means of a rapid initial assessment [37]. The steps required for its application are:
    i. A selection of representative samples of the page to be evaluated.
    ii. Manual evaluation of samples in different browsers.
    iii. Manual evaluation in specialized browsers (text browsers, with voice synthesis, among others).
    iv. Use of an automatic evaluation of accessibility tools.
    v. Summarization of results.

• Conformity assessment: assessment of a page and its conformity with WAI guidelines (WCAG). This combines the use of automated evaluation tools and manual testing accessibility. The activities that make up the conformity assessment are:

1. Determining the scope of evaluation: the identification of the compliance level of the WCAG to be reached (A, AA or AAA) and the selection of representative samples of the pages to be evaluated.

2. Using automatic assessment tools:

(a) Validation of the markup used (HTML or MathML2).

(b) Validation of the use of style sheets.

(c) Use of accessibility tools for automatic evaluation (at least two).

3. Manual Evaluation of samples:

(a) Review of the compliance of pages according to the WCAG checkpoints determined as evaluation research.

(b) Manual evaluation of the samples in different browsers.

(c) Manual evaluation of the samples in specialized browsers (textual browsers, with voice synthesis, etc.).

(d) Verification of the level of simplicity and clarity of the text content displayed.

4. Summarization of results.

- Evaluation with users: the participation of users in the evaluation process is seen as a type of aid for developers, so that they are able to understand how disabled users interact with the system through assistive technologies [37].The issues raised in this assessment are classified, according to their respective causes, into: content markup problems without availability features in the Assistive Technology being used, the user's unfamiliarity with the Assistive Technology and common usability problems involving all users . The steps involved in the development of this type of evaluation are:

1. To conduct a preliminary evaluation of accessibility on the site.

2. To evaluate the user informally, analyzing his use of the web application, as well as considerations about the interface presented; or to apply formal usability testing with a performance analysis of site use.

Certain authors have questioned the validity of the guidelines established by the WCAG, regarding the clarity and objectivity of the document. For example, [8] have reported that accessibility evaluators with advanced experience produced 20% false positives in a conformity assessment using the WCAG and were unable to identify 32% of real problems on a website [6] . For [20] have also pointed out that the generic and vague terms used in the description of technologically-neutral design solutions in the WCAG 2.0, may hinder the understanding and interpretation of the guidelines [19].

In this context, these constitute technical proposals which consider user interaction as a form of ensuring accessibility. Contexts of use are utilized as assessment variables (user categories, usage scenarios and user objectives) [8] as well as tests with users [30], [38]. Of these techniques, the following are highlighted:

- Think aloud: this technique consists of the qualitative reviews of a particular interface, through the analysis of comments voiced aloud by users during interactions with the system [5], [22]. This technique consists of the following steps:

1. Determination of the contexts in which the tests will be carried out (characteristics of users, Assistive Technologies to be used, interfaces to be evaluated, system-usage scenarios, tasks to be performed, among others).

2. Implementation of the tasks previously established on the site interface. During this step, it is established that users will narrate their thoughts (or think aloud) according to the application being used.

3. Evaluation of a list of issues generated from the analysis notes, video recording and audio of the test session (performing the tasks). The degrees of severity for each of the problems found must also be presented.

- Barrier Walkthrough: The accessibility inspection technique in which the context of website use is explicitly considered. An appraiser must identify a number of accessibility barriers, according to the context being evaluated, which are interpretations and extensions of well-defined principles of accessibility [7] . This

technique was developed on the basis of the cognitive path (the usability-of-inspection technique) [27] . The following activities must be carried out during the execution of this technique [6]:

1. Survey of the contexts of use of this application (characteristics of users, usage scenario, activities to be performed and objectives of interaction with the application).

2. Assessment of the presence of barriers according to a given context being evaluated. This step must be performed for each of the contexts considered in the first step.

3. Preparation of a list of problems associated with certain contexts, their respective levels of severity and the performance attributes affected (efficiency, productivity, satisfaction and safety).

- User testing: a quantitative evaluation technique related to user performance in the use of an application; it is a form of empirical evidence of the effectiveness of this checkpoint. [38] used this method of assessment by analyzing the times required to complete certain tasks on sites that adequately use “heading” markup elements and those that do not do so.

The involvement of users with disabilities makes the accessibility of the implementation processes more effective and efficient; however, forming a group of different users with the same level of disability and profile has proved to be a lengthy and complex process. Even large-scale studies would not be able to cover the entire range of deficiencies, existing adaptation strategies and Assistive Technologies. Thus, the evaluation through user-centered approaches, in accordance with the WCAG, is considered to be one of the best ways of evaluating the accessibility of web applications today.

4.3 Accessible Virtual Learning Environment

The debate on accessibility and digital inclusion issues has included government representatives, civil society, and educational institutions, among others, in countries around the world. Due to the incorporation of technological resources in daily life, thus facilitating access to information, learning, leisure, personal and social relationships, the use of these resources has intensified. It is important that these resources are to inclusive elements, so that people can make use of them in an autonomous and independent way.

As an interface for learning, Virtual Learning Environments (VLE) must have software quality criteria, particularly concerning accessibility and usability, in order to allow the elderly or the disabled to use and benefit from such teaching and learning environments.

Accessibility in VLE is a concern for researchers, teachers and organizations, which develop methods for the expansion of education and professional qualification. Yet many more studies must be conducted, so that more people with disabilities will be able to share, interact and contribute to an improvement of these environments.

Accessibility needs to be considered broadly; however, the fact that a computer system interface is designed to comply with principles, standards and accessibility guidelines are of little use to certain users. An accessible interface should respect the differences between people in the design of its products and environments, without stigmatizing or

excluding. This is, undoubtedly, a challenge for the area of the HCI, which researches the methods and techniques that assess these virtual environments and contribute to their improvement.

In [25] article , the author points to the difficulty of introducing changes to communication accessibility; this is due far more to the lack of knowledge concerning what is required to create an accessible environment and how to execute the required action, rather than as a result of the absence of the technologies required for such changes. It is noteworthy that in this study one can adopt accessibility features related to communication for people with visual impairment in virtual learning environments. Furthermore, VLE users can help other people with or without disabilities [25].

The [11] article presents the results of quantitative and qualitative evaluations obtained from a distance for the Web-learning environment. Using an IHC area approach, developed according to the general principles of accessibility and the interaction touchscreen (multi-touch) and described in the recommendations of Design Guidance, users with visual impairments may make use of this system. The results presented provide motivation for further research on multi-touch use by other people with special needs, besides the visually impaired. The IHC area approach also allows for the investigation of other types of interactive interfaces, as they can be adjusted to the needs of each new situation that will be developed.

In the last two decades a great investment has been made to explore and research the benefits of adaptability and accessibility in e-learning. Thus, a large number of projects and research systems have been developed and these have been using accessibility for some of the functions of the learning environment. Unfortunately, not all VLE have attributes that match the needs of specific users, both of which act as a motivation for research in the area. Most popular e-learning platforms do not yet possess accessibility and usability, possibly because the expected profit still does not justify the high effort required for implementation and the authoring of adaptive courses. Furthermore, most systems do not support adaptive e-learning patterns [26].

According to the survey by [23], the Moodle platform has attributes of accessibility and usability for the inclusion of the visually impaired. This author pointed to the need for some technological adjustments in software and for other changes of an educational and instructional nature.

5 CONCLUSION

One thus concludes that there are many guidelines and recommendations for accessibility in the development of web applications, and which can be used in e-learning environments. However, developers are not aware of all the technical details required to implement these recommendations. Despite the number of research studies on the topic of accessibility in virtual learning environments, there is still much to develop.

In addition, more research should be conducted in order to validate accessibility evaluation strategies in learning environments, which should significantly contribute to results that allow for the broad inclusion of new users in learning platforms.

ACESSIBILIDADE COMO ELEMENTO DE INCLUSÃO SOCIAL E DIGITAL ATRAVÉS DO DESENVOLVIMENTO DE AMBIENTES VIRTUAIS DE APRENDIZAGEM NO USO DAS TIC NA SOCIEDADE

RESUMO: Este artigo define o termo acessibilidade em seus diversos aspectos e discute sua importância como elemento de inclusão social e digital, bem como o uso das TIC (Tecnologias da Informação e Comunicação) na sociedade. Descreve os recursos de acessibilidade da Web, padrões de relatório e recomendações de acessibilidade, como o World Wide Web Consortium (W3C) e a Organização Internacional de Padronização (ISO) e especificações. Lista as especificações relacionadas ao software de acessibilidade. Apresenta os tipos de avaliações de acessibilidade da Web, diferencia as ferramentas automáticas das manuais e, finalmente, aborda a acessibilidade aos ambientes de aprendizagem. Expõe o impacto de todas essas análises no desenvolvimento do e-learning. Concluiu-se que existem diretrizes e recomendações para acessibilidade no desenvolvimento de aplicativos da Web e que estas podem ser usadas em ambientes de e-learning. No entanto, há um hiato entre o saber dos desenvolvedores e estas recomendações convencionadas. Há que se empreender mais pesquisas neste campo para validar estratégias de avaliação da acessibilidade em ambientes de aprendizagem, o que provavelmente contribuirá para a inclusão de novos usuários em plataformas de aprendizagem.

Palavras-chave: acessibilidade, AVA, TIC, e-learning, inclusão social e digital.

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