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Revista de Ciências Jurídicas
e-ISSN: 2317-2150
Universidade de Fortaleza

People with disabilities, accessibility and technology: among possibilities and challenges for inclusion*

Pessoas com deficiência, acessibilidade e tecnologia: entre possibilidades e desafios para a inclusão

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Abstract

With the internalization of the International Convention on the Rights of Persons with Disabilities in Brazil with constitutional hierarchy, and the subsequent edition of the Statute of the Person with Disability, the issue of accessibility became the object of greater attention, especially because of the close relationship it has with the process of social inclusion of this group of people. This paper aims to analyze how technology, based on the premise that accessibility is an indispensable condition for people with disabilities to enjoy their rights and carry out their life projects, in a full way with dignity and on equal conditions with other people, especially the resources of assistive technology available, can help overcome barriers, while the universal design is not yet totally undertaken. Developed through the deductive method and bibliographic procedure, the research allowed the conclusion that, in Brazil, although there are countless technological resources aimed at guaranteeing accessibility, at several levels, people with disabilities are still deprived, paradoxically, of access to these instruments, due to several socioeconomic factors. However, given the potential of technology in the inclusive process, which advances towards universal design, developing possibilities for ubiquitous accessibility, the importance of insisting that more and more people have access to it is stressed, as well as the indispensability of mutual efforts between society and the State, to overcome all factors that prevent the full inclusion of people with disabilities in social life.

Keywords: Accessibility. Ubiquitous Computing. Fundamental Rights. People with Disability. Assistive Technology.

Resumo

Com a internalização da Convenção Internacional sobre os Direitos das Pessoas com Deficiência no Brasil, com hierarquia constitucional, e posterior à edição do Estatuto da Pessoa com Deficiência, a questão da acessibilidade tornou-se objeto de maior atenção, mormente pela estreita relação que guarda com o processo de inclusão social desse grupo de pessoas. Partindo da premissa de que a acessibilidade é condição imprescindível para que pessoas com deficiência usufruam de seus direitos e realizem seus projetos de vida de forma plena, com dignidade e em igualdade de condições com as demais pessoas, o presente trabalho objetiva analisar de que forma a tecnologia, em especial os recursos da tecnologia assistiva disponíveis, pode auxiliar na superação de barreiras, enquanto o desenho universal ainda não estiver plenamente empreendido.

*O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001. Artigo traduzido por Inteligência Artificial.

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Desenvolvida através do método dedutivo e procedimento bibliográfico, a pesquisa permitiu concluir que, no Brasil, embora existam inúmeros recursos tecnológicos voltados à garantia da acessibilidade, em diversos níveis, pessoas com deficiência ainda são privadas, paradoxalmente, do acesso a esses instrumentos, por diversos fatores socioeconômicos. Contudo, diante do potencial da tecnologia no processo inclusivo, que avança rumo ao desenho universal, desenvolvendo possibilidades para uma acessibilidade ubíqua, reforça-se a importância em insistir para que cada vez mais pessoas tenham acesso a ela, assim como se ressalta a imprescindibilidade de esforços mútuos entre a sociedade e o Estado, no sentido de superar todos os fatores que impedem a plena inclusão das pessoas com deficiência na vida social.
Palavras-chave: *Acessibilidade. Computação Ubíqua. Direitos Fundamentais. Pessoas com Deficiência. Tecnologia Assistiva.*

1 Introduction

The struggle of people with disabilities for inclusion is historic. For a long time, disability was treated from the perspective of the medical or rehabilitative model, based on the idea that disability consists of an individual's problem, which needs to be treated or cured. This way of understanding the issue of disability contributed to the creation of a social stigma that culminated in an intense marginalization of this group of people.

Within this context, these people were subjected to all kinds of deprivations, which can be verified and brought together in an easily verifiable problem: where are the people with disabilities? Its absence in public spaces and community life is latent, even today.

Aware of this exclusionary scenario, the United Nations (UN) approved the International Convention on the Rights of Persons with Disabilities, which, in its text, inaugurates a new paradigm: the social model of disability. What stands out about this model is that it breaks with the idea that disability is an individual's problem, by recognizing that in all societies there are barriers, not only physical or architectural, but also attitudinal, cultural, technological, and other natures, which prevent the participation of people with disabilities in social life. as well as their own full development as a person.

One of the principles of this Convention is that of accessibility, precisely because of its intrinsic relationship with inclusion. In Brazil, in addition to the internalization of the Convention with constitutional status, in 2015, Law No. 13,146 (Statute of Persons with Disabilities) was approved, which includes an entire title focused on accessibility and its developments, including the intention of consolidating universal *design*.

In view of the new legal scenario that is presented, as well as the deficient reality of accessibility in a broad sense that is still present in Brazil, it is questioned how assistive technology resources can contribute so that people with disabilities – whether physical, mental, intellectual or sensory – can act with greater autonomy and independence, and thus enjoy their rights in equal opportunities with other people.

The work follows the deductive method and the procedure of bibliographic research, starting from the legal construction of accessibility for people with disabilities in the national legal system to then associate it with the use of technological resources. The work plan was divided into three parts: the first deals with accessibility and its conformation in the Brazilian legal system, especially after the International Convention on the Rights of Persons with Disabilities and the Statute of Persons with Disabilities; the second part relates the accessibility to technological resources, with emphasis on assistive technology, explaining the possibilities, but also the limits of the use of such resources; Finally, the third part presents the notion of ubiquitous accessibility, as a proposal for a promising future compatible with the general rule of universal design, in which the person with disabilities, supported by technology in a broad way, will finally be included in society and will be able to fully enjoy all environments and all their rights on equal terms with other people.

2 Accessibility as a prerequisite for the inclusion of people with disabilities

Accessibility and inclusion go hand in hand. The importance of the issue of accessibility is evidenced by statistical data that indicate that the "minority" referring to people with disabilities, in quantitative terms, exceeds the mark of one million people in the world, according to data from the World Health Organization (WHO), in 2011[1]. In Brazil, data from the Census carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 2010 indicate that, at the time, there were more than 45 million Brazilians who declared to have some type of disability[2].

Despite the expressive numbers, as well as the legal protection for people with disabilities, this group of people continues to have their rights systematically violated, even by the government, which is silent in the face of various situations, which demonstrates that the culture of invisibility has not yet been overcome in the country (Barboza; Almeida Junior, 2017, p. 33). The restricted enjoyment of rights is largely due to the lack of accessibility (Leite; Piva, 2019, p. 333).

The lack of accessibility faced by people with disabilities in public spaces, urban furniture, transport, media, information, technologies and signage is one of the main factors that

[1] Data available at: https://nacoesunidas.org/acao/pessoas-com-deficiencia/. Accessed on: 21 set. 2020.

[2] The 2010 Census had as its conceptual framework the International Classification of Functioning, Disability and Health (ICF), released by the World Health Organization (WHO) in 2001. Available at: https://www2.camara.leg.br/atividade-legislativa/comissoes/comissoes-permanentes/cpd/documentos/cinthia-ministerio-da-saude. Accessed on: 21 set. 2020.

prevent their full inclusion in society. Not by choice, they are often restricted to confinement in their homes, not always adequately adapted, or in treatment clinics (Leite; Piva, 2019, p. 332). The maintenance of this exclusionary context supports the "second-class citizenship" historically experienced by people with disabilities[3].

According to Leite and Piva (2019, p. 333) "the term accessibility indicates the condition of free access, of possibility". It is the possibility, guaranteed to each and every person, to enjoy, with autonomy and safety, urban equipment and furniture, means of transport, buildings, public services, as well as available technologies and information systems (Araujo; Maia, 2016, p. 227).

In Brazil, the first technical standard on accessibility was NBR 9050/1985, which provides for the "adequacy of buildings and urban furniture to the disabled".[4] Three years later, the Brazilian Federal Constitution of 1988 was promulgated, which expressly deals with the issue of accessibility in Articles 227, §2 and 244, determining the elaboration of a normative act that disciplines the construction and adaptation of public places and buildings for public use and the manufacture of public transport vehicles, in order to ensure adequate access for people with disabilities[5].

After the Constitution, several laws and decrees were published in Brazil regulating the discipline related to the theme of accessibility. As examples, the following can be cited: Law No. 7,853/1989, which instituted general rules aimed at ensuring the full exercise of the individual and social rights of "persons with disabilities", and their effective social integration, in addition to providing for the creation of the National Coordination for the Integration of Persons with Disabilities (CORDE); Law No. 10,098/2000, which established general standards and basic criteria for the promotion of accessibility for people "with disabilities" or with

[3] The expression "second-class citizenship" is used by the author Joyceane Bezerra de Menezes (2020, p. 574) when mentioning situations of exclusion from participation in civil life, mitigation or suppression of civil capacity, and disrespect for personality, property, will, and autonomy, experienced by people with disabilities over time.

[4] Currently, NBR 9050 is in its third edition (2015), which operated a technical revision in the previous edition (2004). In the current version, its scope is "to provide the autonomous, independent and safe use of the environment, buildings, furniture, urban equipment and elements to the largest possible number of people, regardless of age, height or mobility or perception limitation". Unlike the original wording, it no longer restricts the treatment of accessibility to people with disabilities (NBR 9050:2015).

[5] In addition to the issue of accessibility, the Brazilian Federal Constitution of 1988, in several provisions, gave specific treatment to people with disabilities. There are provisions related to the reservation of a percentage in public positions and jobs, to specific retirement criteria, to social assistance, to the guarantee of a minimum wage of monthly benefit, and to specialized educational care, preferably provided in a regular school network. Despite the relevance of such provisions, in the sense of breaking with an exclusionary history, it is noted that they have an eminently assistentialist content, and, consequently, aim at the integration of people with disabilities into society. However, integration is not enough; it is necessary to include (Barboza; Almeida Junior, 2017, p. 20).

reduced mobility; and Law No. 10,436/2002, which recognized the Brazilian Sign Language – LIBRAS as a legal means of communication and expression.

The demands for accessibility have become increasingly emphatic. Organized civil society, especially through social movements, began to exert pressure so that the issue of accessibility, and, more broadly, the social inclusion of people with disabilities, becomes the object of attention of the public authorities, so that inclusive public policies can be developed (Pimentel; Pimentel, 2017, p. 93).

In 2007, an important step was taken towards inclusion within the United Nations: the International Convention on the Rights of Persons with Disabilities (CRPD) and its Optional Protocol were signed at its headquarters in New York, whose main contribution was to promote a paradigmatic change in terms of the treatment of disability, that is, the replacement of the medical paradigm by the social paradigm of disability (Leite; Piva, 2019, p. 336).

The medical model of approaching disability goes back to "the scientific standards of modernity". In this sense, disability reveals itself as a pathological individual condition. By associating disability with disease, in the light of this model, it is understood that disability comes from natural or biological causes, therefore, it can be the object of prevention, treatment and rehabilitation. Thus, if the person with disabilities, unilaterally, is able to "normalize", he will be able to "integrate" into society. The medical model emphasizes individual impediments, and not the limitations imposed by the environment, by society itself, which hinder inclusion (Barboza; Almeida Junior, 2017, p. 25-27).

In response to this finding, the social model of approach inaugurates a renewed conception of disability linked to the inclusive purpose. Thus, according to Heloisa Helena Barboza and Vitor de Azevedo Almeida Junior (2017, p. 21-22), "inclusion, although not incompatible with integration, is distinguished from it by calling society to action, that is, by requiring society to adapt to welcome people with disabilities".

In this sense, the new model conceives disability no longer in an individualized and stigmatizing way, but as a sociological and political concept, attributing to the State, with the collaboration of civil society, the responsibility for eliminating barriers that prevent inclusion. Thus, the objective is the full citizenship of people with disabilities, through the guarantee of concrete equality and dignity for all (Sarlet; Sarlet, 2019, p. 346-347).

In view of this, the social model presupposes the recognition of autonomy and capacity for people with disabilities, on equal terms with other people. Autonomy is conceived in the CRPD as an attribute of humanity itself, which allows the person to take an active role in the

conduct of their own life, even if materialized through support, that is, exercised in interdependence (Menezes, 2020, p. 589-590).

According to Sarlet and Sarlet (2019, p. 347), the social model "is directly related to the theory and practice of Human and Fundamental Rights". The concept of disability, as structured in the Convention[6], is a relational concept, and its pillars are equality and non-discrimination. However, it is not a merely formal equality, but a material equality, which necessarily requires the recognition and respect for difference (Medeiros, 2018, p. 238-240).

Article 2 of the CRPD also signals a new and more comprehensive concept of discrimination, understood as any act of differentiation, exclusion or restriction that is based on disability itself, and that results in the impossibility of exercising, enjoying or having recognized human rights and fundamental freedoms in any area (civil, political, cultural, etc.), emphasizing, yet the refusal to provide reasonable accommodation also characterizes discrimination. Thus, the emphasis is on the requirement that society and the State, together, guarantee the existence of a sufficient and adequate structure for broad and integral accessibility, as an indispensable condition for the exercise of full citizenship (Sarlet; Sarlet, 2019, p. 348).

In summary, the way in which the issue of accessibility was treated from the perspective of the medical model reflected the very conception that was held about disability, seen as an exclusive problem of the individual, disregarding the influence of barriers without their surroundings. Following the medical logic, in order to minimize the difficulties encountered by the subject deviating from the "standards of normality", only palliative measures were adopted. However, with the social model, the focus of the individual is shifted to the relationship that exists between disability and the environment, in addition to highlighting that accessibility matters both for people with disabilities and for other people who are or are, so to speak, outside the "standards" (Asís *et al.*, 2007, p. 63-64).

The social model is based on the premise that the environment – physical, intellectual and attitudinal – built by society is also responsible for disability, as it imposes barriers that prevent people from enjoying their rights. By the way, there has been a lot of talk about these barriers, as something intuitively understandable, but without its own conceptual definition or terminological consensus (Asís *et al.*, 2007, p. 55). For Rafael de Asís *et al.* (2007, p. 56), "*it can be understood as barrera any obstacle that hinders the impitude, in conditions of equal*

[6] Article 1. Persons with disabilities are those who have long-term physical, mental, intellectual or sensory impairments, which, in interaction with various barriers, may obstruct their full and effective participation in society on an equal basis with others.

opportunities and full participation, the access of people to some of the areas of social life".

There is no single classification, used worldwide, about barriers. Thus, the classification proposed by Asís *et al*. (2007, p. 58), based on accessibility scopes representative of the very spheres of social life in which these barriers may arise. They are: mobility; access to goods and services; negative attitudes towards disability; and communication and information.

Mobility barriers consist of obstacles that people with disabilities encounter to move around, by themselves or by means of transport, when they want, for example, to walk through the city streets or take a bus, but are unable to do so due to the absence of the necessary adaptations. Barriers can also be reflected in the absence or difficulty of access to essential goods and services, such as health and education. They can also be attitudinal barriers, that is, resulting from prejudiced attitudes of society towards people with disabilities (Asís *et al.*, 2007, p. 59-61).

Finally, barriers in communication and information are related to the difficulties faced by people with disabilities when operating language, that is, that prevent or hinder them from transmitting or receiving information. In the context of the *information society*, the absence or difficulty of access to the internet or new technologies, for example, are significant barriers to the process of social inclusion of people with disabilities (Asís *et al.*, 2007, p. 60-61).

Likewise, access to clear, objective and accessible information is an essential element in the path to overcoming the social barriers that still hinder full inclusion. The right/freedom to provide and receive information is what allows people to exercise their free and conscious autonomy and their own citizenship. In this sense, access to information is elementary for the achievement of the objectives proposed by the Convention (Barboza; Almeida, 2020, p. 2).

For Menezes (2018, p. 6), according to the proposal of the social model printed in the Convention, "inclusion imposes the use of the medium as a factor of functional integration". The statement is based on the fact that the inclusive movement presupposes that society goes through a process of "rehabilitation", in which barriers are reduced, reasonable accommodations are implemented, assistive technologies become accessible, and other measures capable of promoting the reception of people with disabilities and the optimization of their functionality are employed.

Throughout its text, the CRPD makes numerous references to accessibility. In addition to citing it in its preamble, it is defined in its Article 3 as one of its principles, along with that of full and effective participation and inclusion in society, and others. Also, in Article 9, it establishes that the States Parties have a duty to ensure that people with disabilities have broad

access to environments, goods and services.

The CRPD and its Optional Protocol were ratified by the Brazilian National Congress through Legislative Decree No. 186/2008, in accordance with the rite provided for in Article 5, paragraph 3 of the Brazilian Federal Constitution of 1988, becoming effective at the domestic level with the publication of Decree No. 6,949/2009, with a hierarchy equivalent to that of a constitutional amendment, integrating the Brazilian constitutionality block (Sarlet; Sarlet, 2019, p. 341).[7]

For Leite and Meyer-Pflug (2016, p.144-145), the CRPD consolidates accessibility simultaneously as a principle and as a right of people with disabilities, and imposes on Member States the duty to adopt appropriate measures to implement this "principle-law", given its indispensability for the realization of the human and fundamental rights of people with disabilities.

In a similar sense, Luiz Alberto David Araújo and Maurício Maia (2016, p. 231) prescribe that "accessibility, [...] It is, in addition to a right in itself, a necessary prerequisite for the enjoyment of all fundamental rights by people with disabilities. Thus, there will only be true inclusion if accessibility is guaranteed".

With a view to implementing the commands of the CRPD, Brazil enacted Law No. 13,146/2015 – Brazilian Inclusion Law (LBI), also known as the Statute of Persons with Disabilities (EPD). This law was published on July 7, 2015, and came into force in January 2016. In it, the word "accessibility" appears 72 (seventy-two) times and gained its own title, Title III, which is divided into four chapters and extends from articles 53 to 76.

According to Article 53 of the DPO, accessibility is the "right that guarantees the person with disabilities or reduced mobility to live independently and exercise their rights of citizenship and social participation". From reading the Statute, it is denoted the transversality of the issue of accessibility in this law, as it is related to the guarantee of full exercise of the most varied rights, such as the right to housing, education, health, mobility, access to information, among others (Medeiros, 2018, p. 243).

Attention is drawn to the provisions of Article 55 of the DPO, which determines that projects regarding accessibility, in a broad way, must comply with the principles of *universal design*, with reference to accessibility standards. The legislator presents a definition of *universal*

[7]In addition to the CRPD, Brazil reinforced its international commitment to accessibility by ratifying the Marrakech Treaty, which, like the CRPD, enjoys constitutional hierarchy, and which aims to "facilitate access to published works for people who are blind, visually impaired, or have other difficulties in accessing printed text."

design in Article 3, item II of the DPO, as the "conception of products, environments, programs and services to be used by all people, without the need for adaptation or specific design, including assistive technology resources".

The term *universal design* emerged in the United States, with the architect Ron Mace, who began to use it to refer to the notion that products designed and produced on the market should have characteristics that make them usable by as many people as possible. This concept was developed and deepened in the 1990s, when the *seven principles of universal design* were defined: equitable use; flexibility in use; simple and intuitive use; perceptible information; tolerance to error; low physical effort; and adequate size and space for access and use (Asís *et al.*, 2007, p. 68-69).

Universal accessibility is not an option, but an indispensable condition for all people to be able to exercise their rights, under equal conditions. It is, therefore, essential for the guarantee of equal dignity and for the free development of the personality of individuals (Asís *et al.*, 2007, p. 62).

Accessibility, in the current terms of the country's constitutional and infra-constitutional legislation, is anchored in the principles of autonomy and dignity of the human person, and must be promoted through all available technological resources in favor of the full participation of people with disabilities in all areas of social life, breaking down barriers and realizing the rights to equality and non-discrimination (Sarlet; Sarlet, 2019, p. 349-350).

Considering the breadth of the issue of accessibility, especially when linked to the theme of inclusion of people with disabilities, we then opted for a methodological approach with an emphasis on the relationship between accessibility and technology, specifically assistive technology, whose applicability demonstrates a broad potential to substantially improve the lives of people with disabilities.

3 Socio-digital accessibility and assistive technology resources: between possibilities and challenges

The current legislative landscape in force in Brazil seeks to break with the history of denial of fundamental rights experienced by people with disabilities. To this end, it is important to highlight the relevance that technology tends to play in this process by enabling a higher level of social and economic mobility for these people. This is because there are technological resources that enable an independent life, and the consequent full participation of people with

disabilities in all their aspects (Moura; Conrado, 2017, p. 260-262).

Among the technological resources used as instruments for the feasibility of socio-digital accessibility of people with disabilities are assistive technology resources (Porto; Gianezini, 2019, p. 544). The term assistive technology refers to a set of resources and services that simplify the daily activities of people without disabilities, and that in relation to people with disabilities go further, as they represent the effective possibility of performing daily tasks autonomously, through the expansion of their functional abilities (Bersch, 2017, p. 2).

Strictly speaking, assistive technology is an accessibility instrument that serves not only people with disabilities, but broadly all people who have any type of temporary or permanent restriction. This technology allows for greater independence and interactivity in everyday life, in addition to increasing the possibilities and quality of the enjoyment of public and collective goods. With this, it makes it possible to overcome barriers and contributes to the promotion of social inclusion (Porto; Gianezini, 2019, p. 551).

At the national level, Decree No. 3,298/1999 dealt with assistive technology in its Article 19, but under the designation *technical aids*. In 2006, the Special Secretariat for Human Rights of the Presidency of the Republic (SEDH/PR) established the Technical Aid Committee (CAT), aimed at preparing proposals for public policies and partnerships between the State and civil society regarding assistive technology, as well as promoting actions aimed at qualifying professionals and preparing studies and research on the subject (Bersch, 2017, p. 3-4).

The CAT, based on foreign theoretical references (Portugal, the European Union, and the United States), elaborated, at the time, a concept of assistive technology very similar to the one that was later adopted by Law No. 13,146/2015. Currently, according to Article 3 of the DPO, it is understood as assistive technology or technical assistance

> [...] products, equipment, devices, resources, methodologies, strategies, practices and services that aim to promote functionality, related to the activity and participation of people with disabilities or reduced mobility, aiming at their autonomy, independence, quality of life and social inclusion.

It is extracted from the text transcribed above that assistive technology encompasses resources and services. The services are intended to evaluate, prescribe and guide the use of technologies, in order to promote functional independence of people with disabilities in the performance of the most diverse activities. Assistive technology resources, on the other hand, enable or facilitate communication, mobility, independent access to the computer, carrying out daily activities independently, access to information, etc. (Porto; Gianezini, 2019, p. 545-546).

As noted, it is a broad concept, which aims at accessibility, and ranges from the simplest

adaptations in certain instruments for daily use to more elaborate computer programs. Information and Communication Technologies (ICTs), for example, have been shown to be increasingly relevant instruments for the inclusion of people with disabilities, and can be used "as" assistive technology or "through" assistive technology. A personal computer, for example, will itself be considered an assistive technology resource if it consists of technical aid aimed at achieving a certain objective; on the other hand, it will work through assistive technology resources if other technical aids are essential for its use, such as adapted mice and keyboards and specific *software* (Hazard; Galvão Filho; Rezende, 2007, p. 29-30).

Given the breadth of the concept, there are some classifications that are used in relation to assistive technology. One of them is the didactic classification proposed by José Tonolli and Rita Bersch in 1998, later updated in view of the advances in the areas to which technologies are related. It presents twelve categories of assistive technology resources, according to their functional objectives: i) aids for daily and practical living (grab bars, supports for household utensils); ii) augmentative and alternative communication (communication boards); iii) computer accessibility resources (virtual keyboards with scanning, voice recognition software, typing orthoses, braille printers); iv) ambient control systems (home automation); v) architectural design for accessibility (environments with ramps, elevators, adapted bathrooms); vi) orthoses (to replace missing parts of the body) and prostheses (placed next to parts of the body for better positioning, stabilization and function); vii) postural adequacy (orthostatic stabilizers); viii) mobility aids (wheelchairs, walkers, crutches); ix) aids for the expansion of visual function and resources that translate visual content into audio or tactile information (maps and tactile graphs, screen magnifying software); x) aids to improve auditory function and resources used to translate audio content into images, text and sign language (hearing aids, translator *software* in LIBRAS); xi) mobility in vehicles (wheelchair lifts); and xii) sport and leisure (sound ball) (Bersch, 2017, p. 4-11).

Among the various assistive technology resources, it is also worth mentioning some examples of digital tools and *software* currently available that aim to ensure accessibility for people with disabilities. *Voice Over*, for example, is a *software* that, when activated by touching the screen, interprets and narrates all the details of the screen through audio. The *Xulia software*, on the other hand, works through voice commands, converting everything the person says into text, in order to allow them to search for information, use social networks or make professional use of the internet. Another tool is *Essential Accessibility*, which can help people with moderate mental, physical, or visual disabilities, because, through it, the user can control the computer in

various ways – gestures (head movements), page reader, voice command, and on-screen keyboard (virtual keyboard). Hand Talk is also mentioned, which is a tool that enables communication between people with hearing impairment and their interlocutors, as it works as an instant translator from Portuguese to LIBRAS (Cavalcante, 2019).

However, if, on the one hand, the relevance that the use of assistive technology resources can play in relation to people with disabilities as instruments for eliminating barriers is undeniable, on the other hand, their use is not yet a full and consolidated reality in the Brazilian scenario, due to several factors.

The first factor to be considered is the incidence of high taxes that end up impacting the final cost of assistive technology products/resources. In turn, the high cost of products makes their acquisition incompatible with the economic reality of people with disabilities, who do not have, for the most part, sufficient purchasing power to bear the costs of technologies (Garcia, 2017, p. 54-55)[8]. This economic and financial barrier, in many cases, means that people with disabilities have to resort to social assistance or the Judiciary in search of access to such resources (Porto; Gianezini, 2019, p. 553).

Furthermore, largely related to the economic condition that, as a rule, people with disabilities present, the technological development aimed at this group is unattractive from a capitalist perspective, as it is a market that does not offer the economic stimuli sought by suppliers, namely, the ability to pay and massivity. In addition, legislative pressure is not yet strong enough to boost investments in this sector. Even the public sector still does not satisfactorily meet the needs of this group, despite its expressiveness in quantitative terms (Berrío-Zapata; Saints; Chalhub, 2020, p. 112).

Furthermore, the lack of knowledge about the existence of these assistive resources is also a relevant factor in maintaining the scenario of limited use (Garcia, 2017, p. 39). By the way, the lack of information is one of the biggest obstacles to full inclusion. In 1981, when the UN proclaimed the International Year of Disabled Persons, the issue of accessibility, until then linked to architectural barriers, expanded to the internet and the *web*, with a view to universal access. Digital accessibility, or *e-accessibility*, aims to promote "democratic access to tools, applications and *websites* and their services, so that people with disabilities can perceive, navigate, and interact with the content offered by *websites*" (Berrío-Zapata; Saints; Chalhub,

[8] Regarding the social reality of people with disabilities, the last Census carried out by the IBGE, in 2010, recorded that social inequalities remain in relation to this group of people, as they have lower schooling, occupation and income rates than the population without any of the disabilities investigated. Available at: https://censo2010.ibge.gov.br/noticias-censo?id=3&idnoticia=2170&view=noticia. Accessed on: 21 set. 2020.

2020, p. 105-106).

In the context *of the information society*, information and communication technologies guarantee people with disabilities access to information, the possibility of communication in the digital world and the exchange of experiences. However, reality demonstrates the existence of the phenomenon of digital exclusion, especially in developing countries (Berrío-Zapata; Saints; Chalhub, 2020, p. 101-102). As Magrani (2014, p. 106-107) points out, "digital exclusion most of the time follows the same logic as social exclusion".

For Berrío-Zapata, Santos, and Chalhub (2020, p. 101-102), the digital divide is a layered phenomenon: the first layer refers to the lack or difficulty of access to infrastructure; the second layer refers to the precariousness in the quality, cost, and capacity of computing and connectivity; and the third layer, which occurs even with access to ICT resources, There are still sociocultural barriers that prevent users from noticing and appropriating the possibilities of using these technologies in their favor.

What can be seen is that the attitude of exclusion in relation to people with disabilities has been transposed from the analog world to the digital world. Much of this is due to the fact that society continues to mistakenly associate disability with disability. There is still a denialist stance regarding the potential of people with disabilities to develop skills and contribute to society, when properly supported with equal opportunities (Berrío-Zapata; Saints; Chalhub, 2020, p. 112-113).

It is said that with the advent of the internet, there was a break in physical barriers, as it allows people, even if physically distant, to communicate, carry out projects and carry out legal business. But, strictly speaking, this statement is not supported, at least not fully, because the internet not only has not broken down all physical barriers, but has also brought virtual barriers to the portion of the marginalized population that has not yet been guaranteed access to information and technological and social development (Pirani, 2019, p. 35).

According to Magrani (2014, p. 110), digital inclusion involves two stages. The first is the guarantee of universal access to the internet. But, in addition to access, inclusion also requires digital literacy, that is, it is necessary for people to be able to interact online, so that they can effectively use the internet to their benefit, for example, through education or distance work. To date, both stages still pose challenges for Brazil[9].

[9]In 2018, the Continuous National Household Sample Survey – Information and Communication Technology (Pnad Continua TIC) was carried out, released by the IBGE. Among the results, it was pointed out that one in four Brazilians does not have access to the internet (about 46 million people). As for the reasons, 41.6% of the people claimed that they do not know how to use the network, 34.6% said they were not interested, 11.8% pointed out that the internet access service is expensive, 5.7% mentioned that the equipment needed to access

In summary, it is verified that technology is available and has great potential to benefit people with disabilities. Therefore, the fight against socio-digital exclusion, which still hinders these people's access to technological and assistive resources in a broad sense, is a daily challenge that is imposed on society and the State, with a view to ensuring that people with disabilities enjoy greater levels of accessibility in all areas, including digital, providing them with autonomy, independence, full exercise of citizenship and inclusion.

4 Ubiquitous accessibility: a proposal for the future?

At first, discussions about accessibility were restricted to the structural or architectural dimension. Later, the concept was expanded to the point that, currently, it is related to the concept of *universal design*, whose purpose is the conception of inclusive environments for all people. From the perspective of universal design, the proposal of intelligent environments/spaces emerges, which, through automation, assistive technology and other technological advances, guarantee people their use in an autonomous and safe way, in addition to providing comfort and convenience (Pimentel; Pimentel, 2017, p. 97).

One of the challenging ways to reach an ideal scenario of accessibility is through ubiquitous computing. It is argued that, over time, microprocessors will have such reduced sizes and costs that they can be present in all things, generating unprecedented interconnectivity between devices (Silva *et al.*, 2015, p. 23).

Thus, the phenomenon that has been called "Internet of Things" is a prerequisite for the understanding and implementation of proposals related to ubiquitous computing. According to Magrani (2018, p. 20), the term Internet of Things (IoT) is used to refer to an "environment of physical objects interconnected with the internet through small and embedded sensors, creating an omnipresent computing ecosystem [...], aimed at facilitating people's daily lives, introducing functional solutions in day-to-day processes".

In short, IoT refers to the phenomenon of communication between machines, designated by the acronym M2M (*machine to machine*), which enables various utensils (such as the classic examples of the toaster and refrigerator connected to the internet) and microdevices with sensors that capture data in the environment in which they are inserted (Doneda, 2018, p. 11-

the internet is expensive, and 4.5% pointed out the unavailability of the internet service on site. Although the financial factor was not mentioned as the main reason for not using the internet, the IBGE highlighted the income inequality between households with and without internet access. Available at: https://g1.globo.com/economia/tecnologia/noticia/2020/04/29/em-2018-quase-46-milhoes-de-brasileiros-ainda-nao-tinham-acesso-a-internet-aponta-ibge.ghtml. Accessed on: 21 set. 2020.

12).

Based on this interconnectivity of things, Doneda (2018, p. 12) states that the internet "will not be 'present' only in objects that we can recognize as 'computers', and may even be in paraphernalia that at first seem unsuspected of any technological sophistication".

Through the integration of *hardware* and *software resources*, associated with the Internet of Things, *ubiquitous computing* constitutes a non-intrusive assistive solution that can have great contributions to the daily lives of people with disabilities (Garcia, 2016, p. 14-15).

The term *ubiquitous computing* was coined by Mark Weiser in 1988. In his article *The computer for the 21st century*, published in 1991 in the magazine *Scientific American*, the author mentions that, unlike personal computers, ubiquitous computing corresponds to the existence of small-sized mobile devices, with access to a worldwide information network, which can identify the environment in which they are located. He also points out that ubiquitous computing differs from virtual reality, as the latter is projected as a simulation of the real world, a kind of environment created by the computer, while the former aims to improve the real world through integrated devices (Weiser, 1991).

There are authors who use the terms *ubiquitous computing*, *pervasive computing,* and *mobile computing* as synonyms. On the other hand, there are those who argue that *ubiquitous computing* results from the fusion between *pervasive computing* – that, although invisible, is known to be present in the environment – and *mobile computing* – which concerns the possibility of accessing information anywhere and at any time through equipment such as cell phones and *tablets* (Silva *et al.,* 2015, p. 24).

The characteristics of ubiquitous computing are: invisibility, since technology becomes ubiquitous and imperceptible, diluted in the physical world; proactivity, since the system must anticipate the user's intention; sensitivity to the context, since all processing in a ubiquitous environment depends on the acquisition of information from the environment; natural interfaces between people and computer systems, which is why gestures, voice commands, eye winks, and other signs that may allow interaction between the individual and technology are used; and decentralization, since the ubiquitous scenario is based on mutual collaboration between systems (Silva *et al.*, 2015, p. 24).

Ubiquitous computing aims to create *smart spaces* , in which computers and other digital devices remain integrated into the environment in which the user is, to assist him, invisibly, in carrying out his daily tasks. It is a heterogeneous and dynamic environment, which challenges developers to predict the ways in which the program should behave in different contexts

(Garcia, 2016, p. 20-21).

In addition, ubiquitous computing is based on objects with *embedded software* or mobile equipment, interconnected by wireless networks, and scattered throughout the environment. These are intelligent objects, which, due to the *software* and sensors embedded in them, are capable of perceiving other objects, people, and the environment around them as a whole. As a result, the authors Filippo *et al.* (2011, p. 304) say that "ubiquitous equipment does not divert the individual's attention from what he is doing, does not overload him, does not demand frequent interaction, works silently and discreetly and only reveals itself and acts when necessary".

In view of the emergence of this new computing paradigm, which moves from the personal computer to ubiquitous computing and cloud computing, the concept of ubiquitous accessibility is also being talked about (Tavares *et al.*, 2011, p. 252). According to Garcia (2016, p. 25), ubiquitous accessibility, or *u-accessibility*, designates the assistive solution that allows "accessibility, anywhere, invoking assistive technologies from devices, mobile or not, with Internet access".

There is enormous potential for ubiquitous computing to contribute to the demands for accessibility. One of the possible applications of ubiquitous computing that can benefit people with disabilities is the so-called *smart house* . It is the possibility of the home environment, through home automation, to self-adjust according to various information extracted from the environment itself, such as sunlight, temperature, presence or absence of objects and people in motion and sound. It is also possible for the person with disabilities, directly (by control) or indirectly (by pressure triggers, traction, blowing, voice command, blinking, etc.) to turn on, turn off or make adjustments to electronic devices, open or close windows and doors, make or receive telephone calls, among other possibilities (Bersch, 2017, p. 7).

In order to elucidate the way ubiquitous computing has been thought of and used in the scope of research that relates it to the accessibility of people with disabilities, the following is a project under development since 2009 at the University of Vale do Rio Sinos (Unisinos), called Hephaestus[10].

It is an integrated model, which works from the user's profile, track management and sensitivity to the context. The researchers' idea is to develop a solution that guarantees people

[10]Currently, the project is in the phase of improving support for the accompaniment of wheelchair users in indoor environments. However, according to the project coordinator, Professor Jorge Barbosa, the challenge is to make the system available for large-scale use by users, creating, for example, an assistive smart city. For more information, see: http://www.unisinos.br/noticias/pos-graduacao/projeto-hefestos-tecnologia-para-inclusao-de-pessoas-com-deficiencia. Accessed on: 29 set. 2020.

with disabilities the freedom to move in various contexts (*indoor* and *outdoor*), supported by assistive technologies. Hephaestus has, at its base, four modules: user profile (storage of data containing personal information, their needs and preferences); special needs; contexts (with six components that allow compositions of dynamic contexts); and trails (user history, contexts visited for a period of time) (Tavares *et al.*, 2011, p. 253-254).

In addition, its system has three *software* agents: i) accessibility assistant agent (AAA), which, based on the user's profile and trails, makes the accessibility decision that will be indicated to the user; ii) personal assistant agent (AAP), present on the mobile or embedded device used by the person with disabilities (*smartphones*, *tablets*, *SPOT,* Motes and other devices with internet access) and which, through authentication, allows him/her to enter the ubiquitous environment; iii) communication agent (CA), which delivers the messages sent from the AAA to the AAP (Tavares *et al.*, 2011, p. 254).

To study the model, the prototype Hephaestus *Wheelchair*, an intelligent wheelchair, was developed. Communication between the mobile device and the wheelchair is done through an app. Through it, the user can even control the movement of the wheelchair through on-screen commands. Basically, the objective of Hephaestus is, through the intelligent wheelchair, to inform the user of the accessibility resources (elevators, adapted bathrooms, access ramps, regions where there are adapted buses, etc.) available in a given space and period of time (Tavares *et al.*, 2011, p. 255-257).

Many other applications of ubiquitous computing in favor of people with disabilities could be cited, but, due to the limitations of the work, it is believed that the examples presented satisfy the objective of elucidating the importance of developing such applications.

Finally, it is pointed out that, although smart environments are not yet economically accessible to the majority of the population, it is still important to carry out research and actions that invest in technological development, including the concern of finding lower-cost inputs that enable a significant increase in access by people with disabilities, who can benefit so much from the use of technology.

5 Conclusion

In order for the constitutional commands of equality and dignity of the human person to be implemented, it is necessary to ensure sufficient conditions so that all people can be effectively included in society. Therefore, accessibility is one of the assumptions to ensure inclusion.

Accessibility, in legislative terms, has taken shape over time, especially after the internalization of the CRPD in the national legal system with constitutional *status*, and the entry into force of the DPO, which, together, show that disability is not only in the person, but in society, which imposes barriers of the most different natures, which prevent people with disabilities from exercising full and effective social participation.

Although the duty of the State and society to do everything necessary to eliminate the barriers that prevent inclusion is increasingly emphasized, it is certain that the current scenario is still configured as a moment of transition to a new paradigm of disability. There is still not full adequacy of all environments in order to serve all people indistinctly, that is, the *universal design* is not materialized. On the contrary, many barriers are still verifiable in both physical and architectural environments, as well as digital.

In this aspect, technology proves to be a very effective instrument to promote autonomy, independence and the full participation of people with disabilities in society. The resources of the so-called assistive technology, for example, are numerous, and range from small physical adaptations to *more elaborate* hardware *and* software.

However, even the technological resources that, at first, seem to be the solution to accessibility, cannot provide answers as effective as they could, because they are also not accessible to the majority of people with disabilities. And this is due to several factors, especially the socioeconomic condition of this group, as a rule, made up of people with limited access (again, access!) to financial resources, as well as information. This limitation leads them to a permanent condition of marginalization, given that, by not having accessibility conditions, they find it extremely difficult to insert, for example, in educational environments, and consequently, in the labor market.

With this, what we seek to highlight is that the biggest challenge in relation to accessibility is in society. Technology represents the possibility of a better future for these people, in which they are treated with equal respect and dignity. The potential is many, so much so that there is already talk of intelligent environments – from homes to cities – aiming at ubiquitous accessibility. Technology, without ignoring the reservations and objections that are addressed to it and which are not appropriate to address in this work, must be used to improve people's lives, and it is with this purpose that so much research and scientific efforts continue to be promoted in this field.

However, it is necessary to remember that technology, as well as legislative commands, are not capable, in fact, of eliminating the origin, the "root", of the problem of lack of

accessibility: the social prejudice and misinformation that still permeate society. Respect for difference and recognition of the condition of people with disabilities as citizens worthy of equal respect by society and the State are essential conditions for ensuring accessibility and full inclusion.

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Received: 10.12.2022
Accepted: 12.10.2021