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Proposal for a definition of Universal Digital Accessibility - UDA

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Abstract: The main objective is to establish a conceptual definition of Universal Digital Accessibility (UDA), based on legislation, standards, and specialised literature. The concept of accessibility, originally associated with geography and urban transport, later developed its own theoretical framework within linguistics, and has recently become widely associated with urban mobility. This study takes a qualitative approach, based on a theoretical and normative review, The methodological process was structured in four stages: 1) literature review and analysis; 2) analysis of legislation and standards; 3) structuring and transposition of concepts; 4) Relationship of digital accessibility and artificial intelligence. This study was built on established references in physical accessibility – including standards, legislation, indicators, and foundational concepts, as well as the principles of universal design – integrating them with content related to digital accessibility. Although the term "digital accessibility" already has definitions in certain fields, the innovative contribution of this research lies in the development of a new definition grounded in the convergence of these references. The proposed definition seeks to expand the understanding of digital accessibility beyond websites and online platforms, incorporating multiple perspectives and contexts of application.

Keywords: digital accessibility, universal digital accessibility, definition development, theoretical definition, conceptual definition.

1. Introduction

Accessibility has been widely discussed in several areas of knowledge, such as linguistics, transportation, and urban mobility, and is also one of the main components of Universal Design (Ariel, 1988 and 1990; Hansen, 1959; Koenig, 1974 and 1980; Morris, Dumble & Wigan, 1979; Handy, 2020). In matters of physical accessibility, adapting spaces for people with disabilities has traditionally been advocated (ABNT, 2020). However, the concept of Universal Design, created by Ronald Mace in 1987, proposes a more comprehensive view; from projects to environments, products and services, all must be designed inclusively, catering to everyone, regardless of age, weight, height, motor skills or disabilities (Mace, Hardie & Place, 1991).

In the digital field, debates on the matter of accessibility gained strength with the emergence of concepts and technologies from different decades. Terms such as Artificial Intelligence (AI), first mentioned in the 1950s, and Information and Communication Technologies (ICT), which became popular in the 1980s, became part of the technical vocabulary related to digital inclusion (Brazil, 2024). In the 1990s, the creation of the World Wide Web Consortium (W3C) by Tim Berners-Lee

brought important regulatory milestones, including the Web Content Accessibility Guidelines (WCAG), now in version 2.2, which continue to guide digital accessibility today, particularly regarding websites (W3C, 2025).

Within this context and considering the WCAG, web/digital accessibility often remains restricted to the web environment, focusing on the barriers faced by people with visual, hearing and motor impairments. This delimitation, although fundamental, does not fully cover the various dimensions that impact different audiences' access to digital resources.

This research is justified by the growing relevance of accessibility in multidisciplinary contexts and by the absence, to date, of a consolidated and broad definition of Universal Digital Accessibility, capable of integrating physical accessibility, universal design, and digital technology. The concepts of digital accessibility and universal design share significant similarities; however, certain key aspects are not incorporated into these concepts, such as consideration of physical, digital, linguistic, and communicational dimensions, as well as human diversity and attitudinal, cultural, and informational barriers, ensuring the full and equal promotion, participation and interaction of all people, regardless of their physical, mental, or cognitive characteristics. For this purpose, the world's most significant legislation and standards were taken into account, selected for their historical and political relevance: the United States, for its pioneering role in discussions about accessibility and its global influence; the United Kingdom, for the creation of the W3C and WCAG; and Brazil, for its specific legislative context and because it is the researchers' country of origin, where the research can be applied and initially tested.

The main question guiding this research is: What is the proposed definition of Universal Digital Accessibility (UDA), considering the concepts of renowned authors and the main legislation and standards existing worldwide in this area?

In this way, the core objective was to structure a new definition of UDA, bringing together digital and physical accessibility concepts. The specific objectives were: a) to review the work of well-known authors on the subject; b) to analyse pertinent national and international legislation; c) to examine related technical standards; d) to integrate these elements, formulating a definition for Universal Digital Accessibility (UDA); e) to understand the pros and cons of the relationship between digital accessibility and artificial intelligence.

Considering that there is a gap in the existing literature, and although there are definitions of digital accessibility (Kravchenko et al., 2022; Brazil, 2023), as well as web accessibility (W3C, 2025a), these concepts are largely related only to the digital environment of websites and portals designed specifically for people with disabilities or aimed at the use of government content and services by Brazilians. However, in order to ensure universal digital accessibility, adaptations and measures are first needed in the physical environment.

This article is organised into the following sections: Section 2.0 - Literature review, including accessibility and universal design foundations; Section 3.0 - Methodology; Section 4.0 - Results; Section 5.0 – Discussion; Section 6.0 - Conclusions; Section 7.0 - R eferences and Section 8.0 - Appendices.

2. Theoretical Reference

This theoretical reference covers the areas of universal design, accessibility, technology, and digital accessibility. The Universal Declaration of Human Rights (2025) states in Article 1 'All human beings are born free and equal in dignity and rights'. Article 2 states that it applies to

everyone regardless of genetic or social characteristics, and Article 7 states that 'All are equal before the law and are entitled without any discrimination to equal protection of the law'.

Throughout history, there have been several attempts to define a 'standard man' or 'standard measurements' such as: a) Leonardo d a Vinci's Vitruvian Man, 1490; b) Ernst Neufert's 'Architects' Data', published in 1936, an encyclopaedia of standard measurements related to the body of this so-called 'standard man'; c) Le Corbusier's Modulor, 1948 (Cambiaghi, 2007). Nowadays, we are dealing with exactly the opposite issue: there is no such thing as a 'standard man', and projects, whether environmental or product-related, must account for diverse user groups, making them more inclusive and accessible.

In 1961, in Sweden, nations such as Japan, the United States, and European countries gathered at an international conference with the aim of reducing architectural barriers for people with disabilities (Cambiaghi, 2007). Two years later, barrier-free design was created in Washington, with a commission focused on enabling architectural, urban and equipment designs suitable for people with disabilities or reduced mobility (Cambiaghi, 2007). The concept of barrier-free design evolved into universal design in the US, with the aim of accommodating everyone.

The Centre for Universal Design at the University of North Carolina's School of Design, in the United States, established by Ronald Mace in 1989, defined universal design as: 'The design of products, environments, buildings, and external areas, to be used by all people, to the greatest extent possible, without the need for adaptation or specialised design, in other words, it must have greatest possible extent of usability ' (Mace, Hardie & Place, 1991; Centre for Universal Design; Cambiaghi, 2007).

The same Centre also established the seven principles of universal design: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and usable design for all (Mace, Hardie & Place, 1991; Centre for Universal Design, 2025; Cambiaghi, 2007; ABNT, 2020): 1) Equitable use - same means for all users, without segregating or stigmatising, promoting privacy, safety, comfort, and protection, and providing an attractive environment for all users. 2) Flexibility in use - choice of methods of use, ease of access and use with both hands, facilitating accuracy, precision, and adaptability to the user's pace, considering their reaction times to stimuli. 3) Simple and intuitive use - eliminate complexities, be consistent with users expectations and intuition, make the design easy to understand, adapt to the user's reading ability and skills, and provide information in order of importance. 4) Perceptible information - the design/project effectively communicates the necessary information to the user, regardless of environmental conditions or the user's sensory abilities. Effective communication through different modes (pictorial, tactile, and verbal); clarity of information and instructions, with adequate contrast in the use of space, equipment and elements; increasing the readability of information, so that it can be understood by people with visual or hearing impairments, people who are illiterate, and others; compatibility with a variety of techniques or devices used by people with sensorial limitations. 5) Tolerance for error - the design/project mitigates risks and the undesirable consequences of accidental or unintentional actions. In the first instance, by grouping, isolating and eliminating these elements, with the most frequently used and accessible elements being retained, dangerous elements being eliminated, isolated or protected, and warnings of potential dangers and errors being provided; in the second instance, by minimising errors and focusing more on tasks that require vigilance. 6) Low physical effort - the design/project can be used efficiently and comfortably, with users in a neutral body posture, minimising physical effort and repetitive actions. 7) Size and space for approach and usable design for all - adequate size and space are provided for approach, reach, manipulation,

and use, regardless of the user's body size, posture, or mobility. A clear line of sight to essential elements is provided, together with adequate reach to all components, for any user sitting or standing; variations in hand and wrist size are accommodated; and adequate space is provided for the use of personal assistance or assistive devices.

Universal design focuses on human diversity in the fields of architecture and design, aiming to serve everyone with better ergonomics and considering physical characteristics, abilities, and age groups. It is used in buildings, indoor and outdoor environments, products, software, and services in such a way that they do not require adaptation or specialised design, as they are already designed to be accessible and may include assistive technology features (ABNT, 2020). Terms such as design for all, design for diversity, inclusive architecture, and barrier-free architecture are commonly used to refer to approaches related to universal design, which creates environments that are understandable and usable by most people, rather than only by specific groups within the population, applying this concept across all areas of life: housing, education, work, recreation, transport, etc. (Cambiaghi, 2007). These include elements and solutions that contribute to accessibility in the design of spaces, artefacts, and products, serving people with different anthropometric and sensory characteristics (Brazil, 2004).

Accessibility is integrated to universal design, in other words, it is one of the aspects of universal design (Cambiaghi, 2007; Centre for Universal Design, 2025; ABNT, 2020). The term ‘accessibility’ derives from the Latin word ‘accessibilitas’, meaning: ‘quality of what is accessible, of what one has access to’, or even referring to the properties of a material that enable the social inclusion of people with disabilities, as well as that of any human being, allowing them to see it, use it and comprehend it (Dicio, 2025). The word accessibility also derives from the term accessible, from the Latin ‘accessibile’: that which can be attained, achieved, obtained, or possessed; intelligible, comprehensible, modest, moderate, reasonable (Brazil, 2007).

Accessibility was commonly described as the distance between human activities, considering the spatial separation between them; it also meant reaching a specific activity from a given location via a public transport system (Morris, Dumble & Wigan, 1979).

The term has already been used in linguistic theory, specifically Accessibility Theory, developed by the linguist Mira Ariel, which investigates how speakers choose different expressions to refer to entities in discourse, linking cognitive psychology with linguistic pragmatics to explain sentence structure and the fluency of human communication (Ariel, 1988 and 1990).

Different levels of accessibility are found on the scale of referential expressions in linguistics; for example, low accessibility is characterised by definite descriptions and proper nouns; medium accessibility by demonstrative pronouns; and high accessibility by pronouns and zero anaphora (where the subject is omitted but can be understood from the context) (Ariel, 1988 and 1990).

Ariel (1988; 1990) also identifies three universal principles of decoding: informativeness, rigidity, and attenuation. The referent is considered to be a mental representation stored in the recipient’s memory during an interaction. Informativeness refers to the richer information retrieved from less accessible referents; rigidity refers to the more rigid forms used for referents with low accessibility; attenuation would be the duality between longer forms associated with less accessible referents and shorter forms associated with high accessibility.

Accessibility has been defined by established authors in the field of urban transport and urban mobility and, currently, there are regulations that define its guidelines for the physical environment in most of the world, including: Brazilian standard NBR 9050 (ABNT, 2020), the American with Disabilities Act - ADA (2025), the principles of universal design (Mace, Hardie &

Place, 1991) from the USA, and the Web Content Accessibility Guidelines - WCAG developed by the World Wide Web Consortium - W3C, from the United Kingdom. The term accessibility also has its origins in transport literature, and researchers believed a few years ago, it was both a land-use function and function of transport system performance function (Batabyal, 2016).

Considering a timeline of developments in accessibility: 1959, Hansen defined accessibility as the potential for interaction opportunities, introducing the idea of measuring accessibility (Hansen, 1959). In the 1960s and 1970s, European countries, including Germany, the United Kingdom, and Sweden, as well as the United States, Canada, and Japan began to discuss accessibility and architectural barriers for people with disabilities, and, in 1974, the United Nations established a group of experts in barrier-free design (Cambiaghi, 2007).

Koenig created the 'Economic Theory of Urban Accessibility' (Koenig, 1974 and 1980). The 1980s were marked by Ronald Mace's pioneering work in developing the concept of universal design, as well as the establishment of his Centre for Universal Design at North Carolina State University. However, Mace, Hardie and Place published their work on the concept of Universal Design in 1991 (Mace, Hardie & Place, 1991). The first version of the NBR 9050 was also published in the 1980s (ABNT, 2020).

The Americans with Disabilities Act (ADA) was enacted in 1990 by the United States Department of Justice (DOJ), which is responsible for enforcing and administering this legislation (DGS, 2025). Also in the 1990s, the International Organization for Standardization (ISO) created standards established technical committees to provide technical assistance on the subject, in 2021, the International Organisation for Standardisation (ISO) published ISO 21542:2021(E) on accessibility and usability of the built environment (ISO, 2021). The Pan American Standards Commission (COPANT) approved the first accessibility standards (Cambiaghi, 2007; COPANT, 2025). The first version (1.0) of the WCAG (Web Content Accessibility Guidelines), developed by the W3C, was published in 1999 and focused on making websites more accessible to people with disabilities (W3C, 2025c).

In Brazil, the main technical standard concerning accessibility, in addition to other legislation on a national, state, and municipal level - is the NBR 9050/2020, published by the Brazilian Association of Technical Standards (ABNT). This norm 'establishes technical criteria and parameters to be observed in the design, construction, installation and adaptation of urban and rural environments and buildings, in terms of accessibility conditions' (ABNT, 2020, p. 1).

The concept of accessibility according to standard is the possibility and condition of reaching, perceiving and understanding, for the safe and autonomous use of spaces, furniture, urban equipment, buildings, transport, information and communication, including their systems and technologies, as well as other services and facilities open to the public, for public or private use, for collective use, both in urban and rural areas, by people with disabilities or reduced mobility (ABNT, 2020, p.2).

NBR 9050 (ABNT, 2020) is comparable to the set of United States legislation comprising the Architectural Barriers Act (ABA), the Americans with Disabilities Act (ADA), and the Uniform Federal Accessibility Standards (UFAS).

The first is the oldest and addresses architectural barriers in federal buildings; the second is the principal accessibility-related civil rights law in the United States, which expanded the scope of accessibility beyond the federal government to areas such as employment, public services, state and local government, commerce, private spaces open to the public, and telecommunications, as well as, more recently, digital accessibility requirements incorporating the WCAG; the third is not

a law, but rather a technical standard concerning architectural measurements and specifications related to circulation spaces, sanitary facilities, and signage.

In Europe, some legislation and regulations are important in these areas, such as EN 301 549, Directive (EU) 2016/2102, and Directive (EU) 2019/882. EN 301 549 is the main technical reference for digital accessibility; Directive (EU) 2016/2102 is a legal obligation regarding digital accessibility in the public sector; and Directive (EU) 2019/882 extends digital accessibility to products and services available on the European market.

According to Sassaki (2009), accessibility is divided into six dimensions: architectural, communicational, methodological, instrumental, programmatic, and attitudinal.

The terminology 'spatial accessibility' refers to the user's ability to understand the function, organisation, and spatial relationships of an environment, participating in the activities carried out there safely, comfortably and independently (Dischinger, Bins Ely & Piardi, 2012). Spatial accessibility is divided into four categories: spatial orientation, communication, displacement, and usage.

Considering accessibility in the field of technology, we must first define the term 'technology', which relates to procedures and methods derived from technical and scientific knowledge and involves processes, techniques, procedures, methods and rules applied to various areas of human knowledge, such as industry, commerce, art, education, among others (Priberam, Michaelis & Dicio, 2025).

Technology has not always been linked to the digital world or to electronics. Since the dawn of mankind, humans have developed methods, techniques and procedures involving objects, in the past, they were not bound to electronics, computing or digital technology. Some examples include: the wheel, hand tools such as hammers, saws, pliers, ploughs, as well as windmills, watermills, sundials, wood-burning stoves, telegraphs, hand looms and Gutenberg's printing press (Basalla, 1988). Thus, the definition of the word 'digital' is complex even for dictionaries, as it includes concepts that may be unfamiliar, and so we will use the more accessible definition of 'digitise', which considers the conversion of analogue data into digital systems, where processing takes place using devices that are usually computers, whereas non-digital aspects are not related to electronic circuits, computers or digital systems (Brazilian Ministry of Education, 2005).

Section 508 was considered relevant to this research due to its relationship with information technology and digital accessibility. This United States legislation is comparable to Brazilian digital government legislation, as both establish accessibility requirements for websites at the federal-level. However, the United States government ([n.d.]) explains that Section 508 is not limited exclusively to federal websites, although it does not apply to private-sector websites.

The WCAG, previously mentioned, aims to provide a single standard for the digital accessibility of web content (websites and web-based tools) that meets the needs of individuals, organisations, and governments internationally, making the web environment more accessible (W3C, 2025c). It consists of 13 guidelines, organised into four principles: perceivable, operable, understandable, and robust, and accessibility is evaluated at three levels: A (low), AA (medium), and AAA (high) (W3C, 2025c).

Among the definitions of digital and web accessibility, the following can be identified: web accessibility allows all people with or without disabilities, older people with 'temporary disabilities', with 'situational limitations', as well as those who have slow internet connections or limited and/or expensive bandwidth, and those who live in rural areas or emerging countries, can perceive, understand, navigate, interact, and contribute to the web, i.e., websites, tools, and

technologies that are developed with inclusion in mind (W3C, 2025a). 'The Web is fundamentally designed to work for all people, whatever their hardware, software, language, location, or ability' (W3C, 2025a).

For Kravchenko et al. (2022), digital accessibility enables access to digital infrastructure, as well the computerisation of public institutions and services in accordance with current regulations and legislation. For Brazil (2023), digital accessibility means eliminating barriers on the web, in other words, websites and portals must be designed in such a way that everyone can access, understand, navigate, and interact effectively with web pages. This definition is part of Brazil's digital government initiative, whose goal is to ensure access, comprehension, and control when navigating government content and services.

3. Methodology

This study takes a qualitative approach, based on a theoretical and normative review, aiming to build a robust conceptual definition of universal digital accessibility. The methodological process was structured in three stages: 1) literature review and analysis; 2) analysis of legislation and standards; 3) analytical and comparative conceptual synthesis; and 4) analysis of the relationship between digital accessibility and artificial intelligence.

The selected sources are justified as follows: dictionaries clarify the general meaning of the term; legislation establishes its legal and institutional meaning; standards demonstrate technical and operational requirements; and academic literature emphasises its scientific conceptualisation.

3.1. Review and analysis of academic literature

Concepts from relevant authors with significant historical contributions in the areas of universal design, accessibility theory, accessibility, urban accessibility, universal design, and digital and web accessibility were used. This stage consisted of an analysis of definitions and concepts of accessibility in a variety of fields, such as linguistics, transport and mobility, Table 1, Appendix A.

3.2. Analysis of legislation and technical standards

Brazilian and international legislation was consulted, including technical standards published by renowned bodies, such as the Americans with Disabilities Act (ADA), and Section 508, in addition to Brazilian documents such as the Brazilian Inclusion Law (LBI) and standards from the Brazilian Association of Technical Standards (ABNT). International guidelines were also included, such as the WCAG, developed by the W3C. At this stage, Brazilian legislation on 'accessibility' and 'digital' was obtained from the Brazilian federal legislation websites (Brazil, 2025) and state legislation websites (São Paulo, 2025), as well as Brazilian standards (ABNT, 2025). This search was conducted between March 23 and April 5, 2025. The number of results found to each theme and selected are presented in Appendix B. The criteria for inclusion and exclusion of sources prioritised documents with technical or scientific backing, official publications in the field. Additionally, normative documents that are effectively applied or commonly used as references by public bodies and international institutions were selected.

The following inclusion criteria were defined: a) Only legislation containing the keywords 'accessibility' and 'digital' in the preamble was included; and b) legislation containing definitions of concepts such as 'accessibility' and 'digital' or related aspects such as 'barriers', 'universal design', 'communication' or any other issues related to the digital environment. The following exclusion criteria were defined: a) Legislation repealed in its entirety; b) Legislation on specific

subjects that are not related to the research topic, and c) Legislation that does not define the concept.

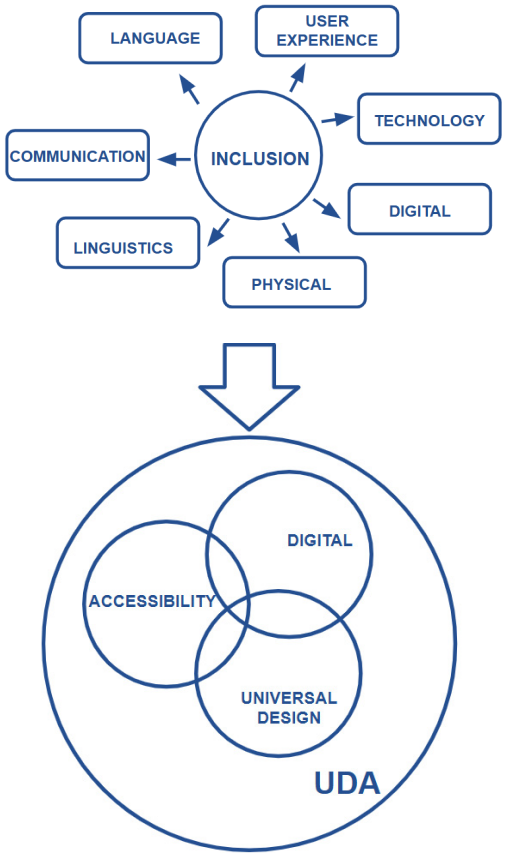
Thus, the research was conducted on the official websites of government bodies responsible for legislation and the standards of the Brazilian Association of Technical Standards legislation and standards of the Brazilian Association of Technical Standards.

3.3. Analytical and comparative conceptual synthesis

After analysing and systematising the theoretical and normative material, the concepts extracted were compared, grouped, and reinterpreted in the light of the principles of universal design, aiming to go beyond the limits of traditional digital accessibility. This stage culminated in the formulation of the proposed definition of Universal Digital Accessibility (UDA).

Figure 1 shows that UDA evolved from the term inclusion and its association with other terms, such as language, user experience, communication, digital, physical, and linguistics, towards a concept based on three relevant terms: accessibility, digital, and universal design.

Figure 1. Diagram – from Inclusion to UDA.



Despite digital accessibility, universal design, and accessibility having different meanings, and considering that the first is applied to technical aspects, interfaces, and digital interaction, while the second is applied to physical environments and products, particularly in relation to people with disabilities, they have a guiding thread that enables them to form an integrated model of accessibility that addresses conceptual gaps that current models cannot address in isolation. More than a combination of terms (universal design and digital accessibility), UDA is a structure that connects, through a systemic approach, physical and digital environments, communication,

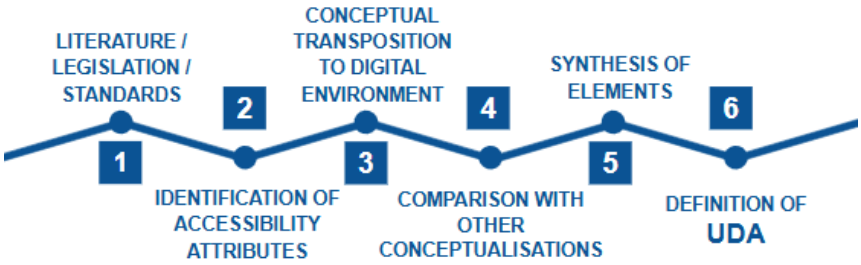
language, technology, user experience, and linguistics in hybrid ecosystems, considering human diversity and informational, cultural, and attitudinal barriers.

An analytical and comparative procedure was undertaken to develop the definition of UDA. The analysis began with established definitions and conceptualisations of accessibility, including those originally formulated for physical environments. Their underlying attributes were identified and conceptually transposed to the digital environment, preserving the core meaning of each attribute while adapting its contextual expression.

For example, concepts such as safe and autonomous use, barrier-free communication, and barrier-free access were examined in terms of their applicability to digital environments. These transposed elements were then compared with definitions of digital accessibility, as well as with relevant legislation, technical standards, dictionaries, and academic literature.

The methodological steps were as follows: 1. literature/legislation/standards → 2. identification of accessibility attributes → 3. conceptual transposition to the digital environment → 4. comparison with other conceptualisations → 5. synthesis of the elements → 6. definition of UDA, as shown in Figure 2.

Figure 2. Methodological step-by-step.



This comparison enabled the identification of convergent, divergent, and complementary elements, which were synthesised into the underlying conceptual components of the proposed definition of UDA. Tables 1 to 3, presented in the Appendix, document the extraction, conceptual transposition, comparison, and synthesis of these elements.

3.4. Relationship of digital accessibility and artificial intelligence

To understand the influence of artificial intelligence on digital accessibility was conducted a search in August 2026 using the Web of Science platform with the search strings “digital accessibility” (All Fields) and “artificial intelligence” (All Fields). The search yielded 75 articles, of which 12 were selected. Three additional articles were selected from previous issues of JACCES, considering the theme and the keyword on title, and one was identified through the snowballing technique.

A total of 16 articles were selected and used to discuss and understand the influence of artificial intelligence on digital accessibility nowadays.

4. Results

Like the methods, this section has been divided into four stages, demonstrating the results for each stage: a) review and analysis of academic literature; b) analysis of legislation and technical

standards c) analytical and comparative conceptual synthesis, and d) analysis of the relationship of digital accessibility and artificial intelligence.

4.1. Review and analysis of academic literature

Renowned authors were selected in the fields of universal design, accessibility theory, accessibility, urban accessibility, universal design, and digital and web accessibility, considering the theoretical relevance and historical contribution of these authors to the development of the analysed concepts.

The articles and papers selected in the accessibility theory section were written by the following authors: Koenig, 1974 and 1980; Morris, Dumble and Wigan, 1979; Mace, 1987 and 1991; Sassaki, 2003; Ariel, 1988 and 1990; Bock and Warren, 1985; Sassaki, 2009; and Dischinger, Bins Ely and Piardi, 2012. These include Hansen (1959), who established the operational concept of accessibility related to urban accessibility; Koenig (1974), who developed the economic theory of urban accessibility; pioneers in the development of measurable accessibility indicators related to transport planning (Koenig, 1980; Morris, Dumble & Wigan, 1979); authors of the theory of accessibility in the field of linguistics and reference (Ariel, 1988 and 1990; Bock & Warren, 1985); Mace (1987 and 1991), a pioneer of universal design; and, in Brazil, authors who are important for defining dimensions within accessibility, as well as the concept of spatial accessibility (Sassaki, 2003; Sassaki, 2009; Dischinger, Bins Ely & Piardi, 2012).

Appendix A contains a conceptual table, Table 1, showing the transposition of concepts from the area of physical accessibility to digital accessibility, which were subsequently used in the definition of Universal Digital Accessibility (UDA), the objective of this research, as discussed further below.

4.2. Analysis of legislation and technical standards

Subsequently, Appendix B contains a summary and analysis of the survey of legislation and technical standards that was conducted through official websites, including the legislative website of the Presidency of Brazil (Brazil, 2025), Table 2, the website of Legislative Assembly of São Paulo - Alesp (São Paulo, 2025), and the ABNT collection for Brazilian technical standards (ABNT, 2025).

The number of results found was analysed according to the inclusion and exclusion criteria outlined in the 'method' section; in other words, legislation in force, related to the researched topic, with the keywords 'accessibility' and 'digital' in the preamble and definitions related to the topic.

The initial result of the research carried out on these three main websites, before applying the criteria, was: 3,270 pieces of legislation. After applying the criterion of the presence of keywords in the preamble: the number was reduced to 1,751; of these, 68 adhered to the theme, and 19 contained definitions of concepts. A further four pieces of legislation and standards were then added which, despite not meeting the keyword criteria, adhered to the theme and contained definitions of concepts, resulting in a total of 23 pieces of legislation and standards selected.

Once the legislation and regulations had been selected, concepts were found for terms such as: accessibility, universal design, barriers, digital or electronic media, communication, and information technology. These definitions were grouped together when they specified the same concept and separated when they covered different concepts (Table 3, Appendix B) while the

most relevant items were used in the proposed definition of Universal Digital Accessibility at the end of the study.

4.3. Analytical and comparative conceptual synthesis

In Appendix C, Table 03 presents the source terms for the composition of the definition of Universal Digital Accessibility (UDA).

Considering that accessibility is only one part of universal design, and that the latter is intended to cater to all people and needs, while also taking into account the needs of people with disabilities, this definition also encompasses aspects of universal design, in addition to physical and digital accessibility, which is why it is called 'Universal Digital Accessibility'.

The term 'universal' refers to universal design, considering that digital platforms and tools can already be designed to be accessible to all people, not just those with some type of disability, a role traditionally associated with accessibility. Thus, accessibility (access for people with disabilities) + digital (digital media, websites, platforms, and tools) + universal (derived from universal design; in other words, for all people, regardless of age, height, weight, cognitive characteristics, disability, individual condition, or reduced mobility).

The concatenation of concepts results in the definition of Universal Digital Accessibility - UDA: it refers to the possibility and conditions of access, approximation, reach, perception, comprehension, use, interaction as well as entry into and exit from environments, and access to products, digital programmes, equipment, information, and communication technologies, systems and other digital services, whether for public or private use, individual or collective purposes, in urban or rural areas. This accessibility should occur in a safe, comfortable, and autonomous manner, with clear and effective instructions and communication, for everyone, regardless of anthropometric characteristics (such as height and weight), sensory characteristics (auditory, visual, intellectual, cognitive, among others), age, ability, reduced mobility, or any other individual condition. This includes, where necessary, the use of technical aids and assistive technology resources. The objective of this definition is to promote social inclusion, equal opportunities, the exercise of citizenship, and respect for the fundamental rights of all individuals (Mace, 1991; Brazil, 2000b, 2004, 2009, 2012, 2015, 2024, 2025; ABNT, 2005, 2008, 2012, 2016a, 2016b, 2020, 2022, 2025; Cambiaghi, 2007; São Paulo, 2008; ISO, 2021; Centre for Universal Design, 2025; Brazil, n.d; UFAS, 2025; W3C, 2025).

For this definition to be met, it is necessary to incorporate the following guidelines:

- Guarantee access to devices (computer, notebook, tablet, among others) for users;
- Guarantee access to quality internet (broadband) for users;
- Guarantee training and technical support from information and communication technology professionals in a digital environment (synchronous or asynchronous) to improve users' digital competence or skills;
- Ensure easy access, interpersonal information exchange, and digital interactions (Hansen, 1959; Koenig, 1974; Dischinger, Bins Ely, & Piardi, 2012) for users;
- Reduce the distance between human activities, in other words, reduce the spatial separation between them (Morris, Dumble, & Wigan, 1979) through the internet, in a digital environment;

- Understand the function, organisation, the movement (between websites and digital platforms without barriers), the use, the spatial relations, and the materials of a digital environment (ABNT, 2020; Dischinger, Bins Ely, & Piardi, 2012; Ariel, 1988);
- Ensure the dimensions of accessibility and digital quality are being attended to: a. Without barriers of physical architecture, and digital (architectural); b. without barriers to communication between people, in a digital and physical environment (communicational); c. without barriers on methods and techniques in a digital and physical environment (methodological); d. without barriers of instruments and tools in a digital and physical environment (instrumental); e. without barriers embedded in public policies, legislation, standards, related to a digital and physical environment (programmatic); f. without prejudices, stereotypes, stigmas, and discrimination in society's behaviour towards people in the physical and digital environment (attitudinal) (Sassaki, 2009).

Based on this process, we sought to ensure that the proposed definition was comprehensive, applicable to different digital contexts, and capable of guiding policies, projects, and practices aimed at promoting genuinely inclusive digital environments.

4.4. Relationship of digital accessibility and artificial intelligence

Nowadays, with the advent of artificial intelligence, a number of studies are linking it to digital accessibility or digital literacy, or digital competence.

Inal and Papachristos (2026) conducted a study on the use of Artificial Intelligence in digital accessibility among university students through a questionnaire composed of open-ended questions and divided into three sections: (i) participant information, including gender, level of knowledge, frequency of AI use throughout the day, preferred AI tools, and purposes for using AI; (ii) considerations regarding the use of AI in digital accessibility, including advantages, disadvantages, examples, potential risks, challenges related to AI integration, and ethical and social issues; and (iii) a single question through which students could provide comments, opinions, reflections, and/or criticisms concerning the use of AI solutions to improve the lives of persons with disabilities. The responses were analysed qualitatively through a top-down thematic analysis, resulting in four main themes: (i) Opportunities and Benefits of AI in Accessibility — positive impacts and potential benefits; (ii) Risks and Challenges in AI Integration — risks, concerns, and challenges related to the greater integration of AI into accessibility technologies; (iii) Ethical and Social Implications — how AI may affect privacy, inclusion, and security, particularly regarding bias, transparency, and accountability; and (iv) Promoting AI for Accessibility — strategies and approaches for effectively integrating and promoting AI in accessibility (Inal and Papachristos, 2026). The results demonstrated positive perceptions among participants regarding the integration of AI to improve the lives of persons with disabilities, establishing a bridge between persons with disabilities and digital society through solutions such as image recognition, speech recognition, text processing, natural language processing, and affective computing (Inal and Papachristos, 2026).

Cortês Vieira et al. (2022) conducted a study with elderly tourists in the Algarve region of Portugal in order to assess their digital literacy regarding the use of the internet, Quick Response (QR) codes, and Near Field Communication (NFC) technology. Data collection was carried out through questionnaires administered to 851 older adults aged 60 years or above at Faro International Airport, as part of the ACCES4ALL - Accessibility for All in Tourism (2017 - 2019) project. The methodology employed descriptive and inferential statistical analyses, leading to the following results: (i) the older the participants were, the less they used the internet; (ii) higher levels of

education were associated with greater internet use; (iii) elderly tourists without disabilities used the internet more frequently than those with disabilities; (iv) only a small number of elderly tourists were familiar with the use of QR codes and NFC technology; and (v) a digital exclusion profile emerged, composed of tourists over 80, women, people with disabilities, lower education levels, and rural residents. The study concludes that fostering digital inclusion in smart tourism requires developing interfaces based on Universal Design principles and actively involving older adults in co-design and co-creation processes (Cortês Vieira et al., 2022).

Real-Fernández et al. (2025) link information technology and artificial intelligence to the design of smart learning platforms, ensuring that these platforms can be used by individuals with diverse abilities. The CALM (Customised Adaptive Learning Model) was developed by the lead author of the paper as part of their doctoral thesis in 2022. The model aims to structure a learning environment that is both adaptive to learners' pace and personalised to their individual needs. To achieve this, the model is based on three fundamental pillars: i) the division of competencies and activities; ii) a competency map; and iii) an AI-based decision-making engine. As a practical application and case study of CALM, the authors' research group developed the Khipulearn platform. The methodology adopted in the paper involved conceptual mapping and a theoretical discussion of the model. The authors describe the smart learning platform and explain which aspects of digital accessibility can be applied to it. Three key dimensions were identified: platform accessibility, content accessibility, and compatibility with assistive technologies. The results demonstrate that, to ensure inclusion in smart and visual competency maps, AI needs to operate natively and automatically, taking into account the principles established by international accessibility guidelines, such as Accessible Rich Internet Applications (ARIA), the Authoring Tool Accessibility Guidelines (ATAG), and the World Wide Web Consortium (W3C) (Real-Fernández et al., 2025).

Akeroyd and Merlo (2023) discuss digital accessibility standards and practices in relation to global sustainability goals in university libraries. Their methodology encompasses a general review and qualitative interviews with librarians as a means of diagnosing the challenges involved in transforming printed and digital materials into formats that are readable by screen readers and accessible through Braille. The study indicates that, despite the availability of new technologies and institutional guidelines, libraries continue to face the dual challenge of managing large historical collections while ensuring their accessibility within the academic environment (Akeroyd & Merlo, 2023).

Chakraborty et al. (2023) present a theoretical and conceptual discussion of the role of artificial intelligence as a future tool for the social inclusion of people with disabilities. The authors analyse several AI-based assistive solutions, including voice-activated personal assistants (VAPAs); sensory and language recognition systems, such as image and facial recognition, auto-captioning, and language technologies; mobility and smart hardware, including route-planning and navigation software, assistive prostheses and robotics, robotic arms, prosthetic limbs, and autonomous vehicles; and reading devices and interface adaptations, such as physical reading machines and the transition from physical to digital commands. The paper argues that these innovations can significantly mitigate the digital divide and concludes that AI can enhance the daily autonomy of people with disabilities, transforming the ways in which they communicate and navigate their everyday lives (Chakraborty et al., 2023).

Chemnad and Othman (2024) conducted a comprehensive mapping of the global research landscape at the intersection of AI and digital accessibility for people with visual, hearing, motor, or cognitive disabilities. The methodology consisted of a bibliometric analysis and a systematic

literature review, initially identifying 3,706 scientific publications published between 2018 and 2023. Following a refinement process, 42 high-quality studies were selected. The research revealed that the primary focus of these publications is on the needs of people with visual disabilities, highlighting a significant gap in intelligent solutions addressing other physical or cognitive impairments (Chemnad & Othman, 2024).

Esposito et al. (2026) evaluated the usability of an intelligent conversational assistant called ConWeb, developed by two of the paper's authors in collaboration with Marcos Báez, to facilitate Web navigation for people who are blind or have low vision (BLV). A comparative experimental study was conducted with 30 real users, in which the authors compared voice-based navigation with conventional screen readers, such as NVDA and JAWS. Qualitative and quantitative data were collected using user satisfaction questionnaires, including the Subjective Assessment of Speech System Interfaces (SASSI) and the User Experience Questionnaire – Short Version (UEQ-S). The study demonstrated that, with ConWeb, conversational interaction significantly reduced participants' cognitive effort and physical fatigue by enabling them to ask direct questions and obtain summaries of complex webpage content, thereby outperforming conventional screen readers in terms of facilitating Web navigation (Esposito et al., 2026).

Jaya et al. (2026) evaluated the "Magnetcode" application, which is used to teach concepts of logic and programming (coding), with the aim of facilitating teaching and computational thinking in agricultural projects. The authors employed a qualitative case study with data triangulation, collecting coding logs (digital records), analyses of physical portfolios, and semi-structured interviews with teachers and agricultural educators in Zambia. The research revealed that the use of the tool had positive outcomes and enabled educators to address complex logical challenges, thereby strengthening the integration of technological skills into the local curriculum (Jaya et al., 2026).

Jones and Echeles (2026) investigated the practical accuracy of AI-generated automatic image descriptions in alternative text (alt text) for online courses designed for nursing educators. The methodology consisted of a qualitative evaluation study using reflexive thematic analysis, in which feedback from teaching staff was collected and categorised after they evaluated the descriptions generated by the language model. The results revealed that, although the use of AI was useful for optimising teaching staff's time, the automated drafts contained serious conceptual errors and omitted essential pedagogical nuances. This indicates that its use is beneficial only as an initial assistant and requires critical human validation by a subject-matter expert (Jones & Echeles, 2026).

Moreno et al. (2019) aimed to integrate accessibility and pedagogical quality criteria into the development of Digital Educational Materials (DEMs). The methodology combined empirical case studies, including teacher training workshops, with quantitative analyses of statistical reliability using Cronbach's alpha and the Intraclass Correlation Coefficient (ICC), based on 30 assessments and 15 surveys completed by teachers and educational material evaluators. The authors successfully validated the integrated accessibility model, which provided the basis for the Spanish standard UNE 71362. The authors of the paper are members of Working Group 12 (WG12), which developed this standard. The results demonstrated that the model was statistically reliable, and the authors recommend that accessibility features should not be treated in isolation, but rather incorporated into the pedagogical and technical characteristics of educational content (Moreno et al., 2019).

Nacheva and Jansone (2023) conducted an in-depth technical evaluation of commercial web accessibility assistants (AI-based overlays), including accessiBe, AllAccessible, and UserWay. Using

a multicriteria heuristic modelling approach, the authors employed the Analytic Hierarchy Process (AHP) to rank these technologies, focusing on web developers and users with sensory or motor impairments. The research assigned important heuristic priorities, such as support for assistive hardware, which accounted for 19.3% of the overall relevance, and revealed limitations in these tools, showing that overlays often operate superficially within the user's browser without addressing the underlying problematic code on the servers (Nacheva & Jansone, 2023).

Pereira and Duarte (2025) investigate the ethical, operational, and practical aspects involved in the large-scale monitoring and evaluation of digital accessibility. The methodology employed a mixed-methods approach, combining online questionnaires and semi-structured interviews with 27 experts from 16 countries. The authors interpreted the responses using reflexive thematic analysis. The main findings highlight a gap between technical compliance and the actual user experience, as well as the need to integrate AI technologies and Large Language Models (LLMs) to optimise professional auditing workflows in complex digital environments (Pereira & Duarte, 2025).

Rehman et al. (2024) analysed the impact of ChatGPT use on individuals' life satisfaction in academic settings. The methodology consisted of a structured quantitative study involving 305 higher education students. Using covariance-based structural equation modelling (CB-SEM), the researchers examined the moderating role of subjective well-being in this relationship. The main findings show that daily interaction with artificial intelligence positively influences academic engagement, academic self-esteem, and student resilience, factors that substantially increase students' sense of control and personal satisfaction with their educational experience. The main factors limiting improvements in quality of life in the context of AI use are related to biased responses, limited knowledge, and the lack of emotional intelligence in AI systems, which reduce their perceived reliability and consequently diminish engagement (Rehman et al., 2024).

Santos (2025) evaluated the accessibility conditions of the interface and scientific publications deposited in the RIMA digital repository of the Federal Rural University of Rio de Janeiro (UFRRJ) against W3C criteria and the Brazilian Inclusion Law (LBI). The research was exploratory and applied, incorporating automated auditing using the Brazilian ASES software, conventional semantic and structural scanning, and manual inspection of a sample of 10 recent academic papers in PDF format. The repository achieved a score of 84.53%, classified as regular, due to barriers related to colour contrast, the lack of keyboard shortcuts, and HTML markup failures. Furthermore, the documentary analysis revealed that only one of the 10 dissertation and thesis PDFs was fully accessible to people with disabilities. The study concluded that the use of artificial intelligence resources for audio description and the automatic formatting of PDFs will be urgent and indispensable in the near future (Santos, 2025).

Todorov (2024) discusses the practical limitations and capabilities of generative artificial intelligence tools, such as ChatGPT, Gemini, and Copilot, in assisting content creators in the development of accessible websites. The methodology involved a state-of-the-art review accompanied by programming code tests and alternative image description tasks. The author demonstrated contrasting results regarding the effectiveness of these tools, focusing on designers and users with special accessibility needs. While ChatGPT successfully optimised problematic HTML code for screen readers, Gemini failed to restructure the code and merely suggested additional labels for the original, inadequate code (Todorov, 2024).

Volkmann et al. (2025) mapped how formal levels of technical accessibility in web interfaces directly affect the well-being of individuals with cognitive processing difficulties and disabilities. The authors employed a qualitative methodology based on empirical website usability testing,

structured through individual interviews, with the data categorised using structured content analysis in the MAXQDA software. The results showed that the lack of Easy-to-Read language, excessive dynamic background animations, and complex navigation layouts cause severe disorientation, fatigue, and extreme frustration among these users, demonstrating that cognitive accessibility requires guidelines as rigorous as those addressing sensory disabilities (Volkmann et al., 2025).

The results of a search about the relationship between digital accessibility and artificial intelligence showed that despite the AI helping a lot of people with disabilities, this tool is not so reliable and still needs to be revised by humans.

5. Discussion

The results of this search were a definition of "Universal Digital Accessibility - UDA", as well as the guidelines for ensuring that it is addressed comprehensively. The definition enables the ideal relationship between users and environments, products, equipment, and digital programmes, as well as defining how this relationship should occur and identifying the actors involved in the process. The definition dismisses the "standard human" imposed by Le Corbusier, Neufert and Da Vinci, because it considers people in all their individual characteristics, including age, anthropometrics, sensory characteristics abilities, movements, or any other individual condition (Cambiaghi, 2007; Brazil, 2004).

The definition aims to strengthen the definitions of digital accessibility (Brazil, 2023) and web accessibility definition (W3C, 2025a) making them more robust, not only in relation to barriers on the web or the application of the WCAG on the web (W3C,2025a), but also considering certain physical aspects that precede the digital aspect, as well as not focusing solely on persons with disabilities (ABNT, 2020 and Brazil, 2004), but rather on all persons with diverse characteristics (Mace, 1991).

The guidelines established address physical issues (offline) before digital issues (online) to be met to ensure digital accessibility, such as access to mobile devices; quality of internet; training and technical support; reduction of physical distance through digital proximity; as well as the reduction of architectural, communicational, methodological, instrumental, programmatic, and attitudinal barriers within physical and digital environments.

The term 'universal', derived from universal design, was added to the definition to emphasise that digital environments, products, programmes, and services should not require adaptation, but rather be designed in an accessible manner (ABNT, 2020); allowing people with or without disabilities, older people, people with situational limitations, those using slow or limited internet connections, and those living in rural areas or developing countries to perceive, understand, navigate, interact with and contribute to the web, in others words, websites, tools, and technologies that are developed with inclusion in mind (W3C, 2025a). "The web is fundamentally designed to work for all people, regardless of their hardware, software, language, location or ability" (W3C, 2025a).

The term digital was used in the definition because most of what is covered in this research is related to the digital environment, although the physical environment is not disregarded.

The term 'accessibility' is at the heart of the name given to the definition and is related to the main concepts, whether in the work of recognised authors in the field (Hansen, 1959; Koenig, 1974; Morris, Dumble and Wigan, 1979; Sassaki, 2009; Dischinger, Bins Ely and Piardi, 2012);

standards (ABNT, 2005, 2008, 2012, 2016, 2020, 2022, 2025), Brazilian legislation (Brazil, 2004, 2008, 2012, 2015) foreign standards and legislation (ISO, 2021; ADA, 2025, UFAS, 2025) or international guidelines (W3C, 2025a, W3C, 2025b, W3C, 2025c, W3C, 2025d).

The structure of UDA, as shown in Figure 3, was established through five steps: the search for concepts, national and international legislation, standards, and the main authors on the subject, as well as, at this stage, the influence of artificial intelligence in this field.

Figure 3. UDA Structure.



The aim was to understand how the subject has been discussed and defined in the literature and how it has been addressed by legislation and technical standards.

At this stage, the influence of artificial intelligence in the field was also considered, particularly its potential to improve accessibility and inclusion, as well as the new challenges it may create. This helped to establish the theoretical and normative basis for the following stages of the research.

The Social Model of Disability understands disability as a societal issue rather than an individual problem (Barnes, 1996). The traditional concept that associated disability with the individual, as if the problem lay within the person, is no longer adopted. The recent concept of the Social Model of Disability explains that disability is produced by and is a problem of the environment, communication, technology, and society. The UDA also incorporates this perspective, recognising that all these barriers can occur in both physical and digital environments, and seeks to eliminate barriers in these environments and ensure full participation for all people with diverse characteristics.

Studies on digital accessibility and artificial intelligence have focused on university students, older tourists, and libraries (Inal & Papachristos, 2026; Cortês Vieira et al., 2022; Akeroyd & Merlo, 2023), or have evaluated tools, whether AI-based or not, including applications (Nacheva & Jansone, 2023; Jaya et al., 2026; Todorov, 2024; Volkmann et al., 2025). Other studies have proposed models, platforms, standards, and assistants (Real-Fernández et al., 2025; Moreno et al., 2019; Esposito et al., 2026). More theoretical research has encompassed theoretical and conceptual discussions, bibliometric analyses, systematic reviews, and state-of-the-art surveys (Chakraborty et al., 2023; Chemnad & Othman, 2024; Todorov, 2024). More specific studies have analysed automatic image descriptions (alt text), the life satisfaction of ChatGPT users in academic settings, and the accessibility conditions of scientific publications (Jones & Echeles, 2026; Rehman et al., 2024; Santos, 2025).

This research falls primarily within the category of theoretical studies, with the aim of contributing to the development of a new definition, termed Universal Digital Accessibility (UDA).

6. Conclusions

The research aimed to propose a definition of UDA for three main reasons: (a) Accessibility, especially in Brazilian legislation, only considers people with disabilities or reduced mobility, while ISO 21542:2021(E) and Universal Design consider all people, regardless of physical characteristics, cognitive abilities, age, and skills; (b) in accessibility, the dimensional specifications details established in legislation and regulations define the requirements that should be met to adapt existing environments or artefacts, while in universal design, the artefact is conceived from the outset by considering the principles of physical and digital accessibility for all people; and (c) UDA provides a structure that systemically connects through a systemic approach physical and digital environments, communication, language, technology, user experience, and linguistics within hybrid ecosystems, while considering human diversity and informational, cultural, and attitudinal barriers.

The definition encompassing both concepts—accessibility and universal design—was necessary because, during the research, no definition was found that encompassed both physical and digital accessibility, universal design, and technology.

The review and analysis of the literature led the research to widely recognised authors, while the analysis of legislation and technical standards enabled an understanding of the concepts known and defined by these documents, so that they could be incorporated into the definition of Universal Digital Accessibility (UDA) in a structured manner and through the transposition of concepts, and the research about AI complemented the main research with important perspectives on current technology

In light of this analysis, this study consolidates the following definition of Universal Digital Accessibility - UDA: it refers to the possibility and conditions of access, approximation, reach, perception, comprehension, use, interaction as well as entry into and exit from environments, and access to products, digital programmes, equipment, information, and communication technologies, systems and other digital services, whether for public or private use, individual or collective purposes, in urban or rural areas. This accessibility should occur in a safe, comfortable, and autonomous manner, with clear and effective instructions and communication, for everyone, regardless of anthropometric characteristics (such as height and weight), sensory characteristics (auditory, visual, intellectual, cognitive, among others), age, ability, reduced mobility, or any other individual condition. This includes, where necessary, the use of technical aids and assistive technology resources. The objective of this definition is to promote social inclusion, equal opportunities, the exercise of citizenship, and respect for the fundamental rights of all individuals (Mace, 1991; Brazil, 2000b, 2004, 2009, 2012, 2015, 2024, 2025; ABNT, 2005, 2008, 2012, 2016a, 2016b, 2020, 2022, 2025; Cambiaghi, 2007; São Paulo, 2008; ISO, 2021; Centre for Universal Design, 2025; Brazil, n.d; UFAS, 2025; W3C, 2025)..

This research contributed to the fields of accessibility, the digital environment, and universal design by grouping interrelated concepts into a single concept and providing a more solid and complete definition that meets the principles of digital inclusion.

The research on AI has raised some interesting perspectives, such as greater autonomy for people with disabilities in a digital environment and assistance with creating drafts of alternative text in the educational area. The negative aspects include the potential for AI use to create human dependence, as the technology is not yet fully reliable, as well as the lack of context. AI frequently "hallucinates" information, while ethical barriers, privacy concerns, and algorithmic bias are also issues that need to be considered. The authors argue that AI and intelligent systems still fail to

adequately address the needs of vulnerable populations and those with lower levels of digital literacy.

The limitations of the main study are related to its failure to consider legislation from all countries; the analysis predominantly considered Brazilian, North American and European legislation was considered, but the inclusion of legislation from other continents would make future research more applicable to other realities.

With the consolidated definition of Universal Digital Accessibility (UDA), it is suggested that future research should expand its application to various areas, making it a precursor to the development of definitions such as Universal Digital Accessibility for X, following the Design for X approach.

As future research, it is proposed to apply the proposed definition in the educational, business, commercial, and other areas, as well as at various levels within these sectors and in other related thematic areas, so that the tool can adapt and evolve according to the realities of other countries and researchers.

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Appendices

Appendix A

Table 1. Conceptual

Author (year)	Physical Accessibility	Digital Accessibility
Hansen (1959)	potential for interaction opportunities.	potential for digital interaction opportunities.
Koenig (1974)	allows for exchanges and easy interaction.	allows for exchanges and easy digital interaction.
Morris, Dumble and Wigan (1979)	The distance between human activities, considering the spatial separation between them.	The distance between human activities in the digital environment, considering the spatial separation between them through the internet.

Author (year)	Physical Accessibility	Digital Accessibility
BRASIL (2004) e ABNT NBR 9050:2O20 (Brazilian Association of Technical Standards)	Condition to use with security, autonomy, total or assisted, of the environment.	Condition to use with security, autonomy, total or assisted, of in a digital environment.
Sassaki (2009)	Architectonic accessibility - without physical barriers.	Architectonic accessibility - without digital barriers.
Sassaki (2009)	Communicational accessibility - without barriers to communication between people.	Communicational accessibility - without barriers to communication between people, in the digital environment.
	Methodological accessibility - without barriers to methods and technicians of leisure, work, education, etc.	Methodological accessibility - without barriers to methods and technicians of leisure, work, education, etc, in the digital environment.
Sassaki (2009)	Instrumental accessibility - without instrumental, tool or utensil barriers.	Instrumental accessibility - without instrumental, tool or utensil barriers, in the digital environment.
Sassaki (2009)	Programmatic accessibility - without barriers integrated in public policies, laws, standards, etc.	Programmatic accessibility - without barriers integrated in public policies, laws, standards, etc, in the digital environment.
Sassaki (2009)	Attitudinal accessibility - without prejudices, stereotypes, stigmas and discrimination in society's behaviours towards people with disabilities.	Attitudinal Accessibility: without prejudices, stereotypes, stigmas and discrimination in society's behaviours towards, in physical and digital environment.
Dischinger, Bins Ely and Piardi (2012)	Spatial Accessibility: encompasses the users understanding of the function, organisation and spatial relationships of an environment, participating in the activities developed there with safety, comfort and independence.	Spatial Accessibility: encompasses the users understanding of the function, organisation and spatial relationships of a digital environment, participating in the activities developed there with safety, comfort and independence.
Dischinger, Bins Ely and Piardi (2012)	Spatial orientation: identifies the functions of a space, defines how to implement the movement and use.	Spatial orientation: identifies the functions of a digital space, defines how to implement the movement and use.
Dischinger, Bins Ely and Piardi (2012)	Communication: exchange interpersonal information, with or without the use of assistive technology.	Communication: exchange interpersonal information, with or without the use of assistive technology, in a digital environment too.

Author (year)	Physical Accessibility	Digital Accessibility
Dischinger, Bins Ely and Piardi (2012)	Movement: vertical movement (stairs, ramps and lifts) and horizontal movement with independence, security and comfort, without barriers.	Movement: digital movement between websites, teaching platforms and systems with independence, security and comfort, without barriers.
Dischinger, Bins Ely and Piardi (2012)	Use: effective participation and carrying out activities by all people.	Use: effective participation and carrying out activities by all people, in a digital environment.
Ariel (1991)	Relative accessibility will be constant on every language, and not the absolute degrees of accessibility.	Digital accessibility will be constant in every language, and not the absolute degrees of accessibility.
Ariel (1991)	Accessibility is not only a cognitive concept, but also a linguistic characteristic.	Digital accessibility ought to be cognitive to encompass people with learning difficulties, with intellectual disabilities, autism or ADHD .
Ariel (1988)	Factors affecting antecedent accessibility: a. Distance between the antecedent and the anaphora. b. Number of competitors for the antecedent function. c. Importance of currency in antecedent attributions. d. Role of tables in antecedent identification.	Factors affecting digital accessibility: a. lack of electronic devices b. lack of internet access c. lack of access to learning websites and platforms d. lack of digital skills e. lack of digital skills training f. lack of accessibility of websites, learning platforms and apps.
Ariel (1988)	Three types of contexts (general knowledge, physical environment, and linguistic material).	Knowledge of the use of the digital environment and digital materials (digital skills, websites, learning platform, email, text, documents, audio, images, software, apps, data, downloading and uploading).
Ariel (1990)	Function is fulfilled by the accessible information.	Function of accessible digital information.
Ariel (1990)	Hypothetical connection between what is named accessibility marking and the memory nature can help to understand what happens during the discuss progression in terms of the choose of referential expressions.	Marking of digital accessibility.

Author (year)	Physical Accessibility	Digital Accessibility
Bock and Warren (1985)	Conceptual accessibility is connected to a hierarchy of grammatical relationships that influences the formulation of phrases.	Digital Accessibility is connected to digital access by means of device.
ABNT NBR 9050:2O20 (Brazilian Association of Technical Standards)	Accessible route: a continuous route, without obstruction and signalised, that connects indoor environments to outdoor environments on buildings. Spaces that can be used in an autonomy and safety way for all people, including those with some disabilities or reduced mobility. This route covers car parks, pedestrian crossings, floors, corridors, stairs, and ramps, amongst others.	Accessible digital route: a continuous route, without obstruction that connects digital environments in a way that can be used with autonomy and security for all the people, including those with some disabilities or reduced mobility. This digital route covers websites, learning platforms, email, and digital media, amongst others. The accessible route in a digital environment is to get all the access to every information on websites, learning platforms in an educational and efficient manner to all people.
ABNT NBR 9050:2O20 (Brazilian Association of Technical Standards)	In buildings, essential signage elements include information on toilets, bathrooms, changing rooms, vertical and horizontal accesses, floor numbers, and escape routes.	In digital environment, essential signage elements and digital accessibility are defined by the Web Content Accessibility Guidelines (WCAG).
ABNT NBR 9050:2O20 (Brazilian Association of Technical Standards)	The signage must be arranged in accessible locations.	The signage in a digital environment must be arranged in accessible locations.
ABNT NBR 9050:2O20 (Brazilian Association of Technical Standards)	The Pedestrian traffic lights must be equipped with a mechanism and synchronised devices that have visual and audible signs.	Digital environments must be equipped with mechanisms: audible, screen reader, amongst others.

Appendix B

Table 2. Legislation and standards

Term	Source	Results	Keywords	Alignment to the theme	Conceptual definition
Accessibility	Brazil	310	13	3	2
Accessibility	State of São Paulo, Brazil	157	13	1	1

Term	Source	Results	Keywords	Alignment to the theme	Conceptual definition
Accessibility	Brazilian Association of Technical Standards (ABNT)	61	45	9	8
Digital	Brazil	1249	66	45	5
Digital	State of São Paulo, Brazil	1079	64	4	1
Digital	Brazilian Association of Technical Standards (ABNT)	414	263	6	2
SUBTOTAL		3270	1751	68	19
ADDED					4
DECREE Nº 6.949/2009	Brazil	-	-	1	1
ABNT NBR 15290:2OO5 (Brazilian technical standard)	Brazilian Association of Technical Standards (ABNT)	-	-	1	1
ISO 21542:2021(E)	International	-	-	1	1
DECREE Nº 67.641/2023	Brazil	-	-	1	1
TOTAL					**23**

Appendix C

Table 3. Terms that helped on a definition composition of "Universal Digital Accessibility"

Source	Concepts
Michaelis online dictionary (2025)	Accessibility: Facility to access, quality of what is accessible. Facility of approach, procedure, or obtaining.
ABNT NBR 15290:2OO5, ABNT NBR 9050:2O20), ABNT NBR 15290:2O16, ABNT NBR 15599:2OO8 (Brazilian technical standard). Law Nº 10098:2000 amended by Law Nº 13146:2015, São Paulo State Law Nº 12907:2008	Accessibility: Possibility and condition of reach, perception and understand to use, with safety and autonomy, spaces, furniture, urban equipaments, buildings, transport, communication and information, including systems and technologies, as well as another services and installations open for public, from private or public uses, individual or collective, in both urban and rural areas, from people with disabilities or reduced mobility.

Source	Concepts
ABNT NBR 17060:2O22 (Brazilian technical standard)	Accessibility: The scope in which products, systems, services, environments, and infrastructure can be used by people of a population with a larger variety of characteristics and capacities, to achieve a specific aim in a context of specific use (both the use facility - task efficiency and user satisfaction - and use success, that is, the system effectiveness).
Decree Nº 5296:2004 and ABNT NBR 14022:2O25 (Brazilian technical standard)	Accessibility: Condition for use, with safety and autonomy, total or assisted, spaces, furniture and urban equipment, buildings, transport services and device services, systems and communication environment, and information, by people with disabilities or with reduced mobility.
ISO 21542:2021(E)	Accessibility: Provision of buildings or parts of buildings for people, regardless of their age, size, ability, or disability, to be able to gain access to them, into them, to use them and exit from them. Note 1 to entry: Accessibility includes ease of independent approach, entry, evacuation and/or use of a building and its services and facilities, by all building's potential users with an assurance of individual health, safety, and welfare while those activities.
Law Nº 12587:2012	Accessibility: A facility that enables autonomy for everyone in desired movements, respecting legislation currently in force.
ABNT NBR 15610-2 and -3:2O12 (Brazilian technical standard) - part 2 and 3	Accessibility: Possibility scope for use, with safety and autonomy, in a physical environment, systems and communication environment, products and services, by people with hearing, visual, or intellectual impairment.
Uniform Federal Accessibility Standards (UFAS)	Accessible: a place, building, installation, or part of them that agrees with standards and that can be reached, entered, and used by people with physical disabilities.
W3C	Web accessibility means that websites, tools, and technologies are designed and developed so that people with disabilities can use them. More specifically, people can: a. perceive, understand, navigate, and interact with the Web; b. contribute to the Web. Web accessibility encompasses all disabilities that affect access to the Web, including auditory, cognitive, neurological, physical, speech, visual. Web accessibility also benefits people without disabilities, for example: A. people using mobile phones, smart watches, smart TVs, and other devices with small screens, different input modes, etc. B. older people with changing abilities due to ageing. C. people with “temporary disabilities” such as a broken arm or lost glasses. D. people with “situational limitations”, such as in bright sunlight or in an environment where they cannot listen to audio. E. people using a slow Internet connection, or who have limited or expensive bandwidth.
Mace (1991)	Universal Design: Designing all products, buildings, and exterior spaces to be usable by all people to the greatest extent possible.

Source	Concepts
ABNT NBR 9050:2O20 (Brazilian technical standard) and Law Nº 10098:2000 amended by Law Nº 13146:2015	Universal Design: Conception of products, environments, programs, and services to be used by all people, without adaptation or specific design, including the assistive technology resources.
ABNT NBR 15599:2O08; ABNT NBR 17060:2O22 (Brazilian technical standard); Cambiaghi (2007); Center for Universal Design (2025); Decree Nº 6949:2009	Universal Design: Way to concept products, communication environments, services, and environments to be used by all people, most of the time, without adaptation, benefiting people of all ages and capacities. The concept of universal design has seven principles: 1. Equalisation of use possibilities; 2. Use flexibility; 3. Use simple and intuitive;4. Perceptive information; 5. Error tolerance; 6. Minimum physical effort; 7. Dimensioning of access spaces and use by all users.
Decree Nº 5296:2004	Universal Design: Conception of places, artefacts, and products to simultaneously satisfy all people, with different anthropometric and sensorial characteristics, in an autonomy, safe, and comfortable way, constituting the elements or solutions that constitute accessibility.
Decree Nº 5296:2004; State Law of São Paulo Nº 12907:2008; Law Nº 10098:2000 amended by Law Nº 13146:2015	Barriers: Any obstacle that prevents access, movement, the circulation with safety and the possibility of communication by people and access to information: a. Urban barriers: on streets and public use spaces; b. Building barriers: contemplates barriers that exist around the buildings and indoors, can be buildings of different uses (public or private); c. transport barriers: on transport services; d. Communication and information barriers: any obstacle that prevents the expression or reception of messages by a device, environment or communication system and information.
Michaelis online dictionary (2025)	Digital: From Latin “digitalis”: a device that operates with binary values exclusively, in contrast with an analogue system that operates with a continuous range of values; a greatness assuming integer values; a computer that operates with numeric quantities or expresses information by algorithm; a computer with data processed by a graphic representation. Digitise: change movements or analogue signals to a digital form that can be processed by computers. Digitised: converted to a digital system. Digitisation: a process through which analogue data is digitised.
Digital Government of Brazil (2025)	Digital accessibility: elimination of barriers on the web. The concept assumes that websites and portals are designed for all people, to make them understand, navigate, and interact with effective ways with the websites.
Inal and Papachristos (2026)	Digital accessibility is a field that aims to ensure equal access to online information and services for everyone, regardless of skills and abilities.

Source	Concepts
Decree Nº 12069:2024	Digital Government of Brazil: management approach focused on the transformation of public organisations, supported using digital technologies, with a view to delivering public value to society by improving its processes, the provision of public services and the implementation of public policies.
ABNT NBR 17225:2025 (Brazilian technical standard	Information Technology and Communication - ICT: technology to collect, store, retrieve, process, analyse and transmit information.
United States Government Publishing Office (2011)	Information Technology: any equipment or interconnected system or subsystem of equipment, used in the automatic acquisition, storage, analysis, evaluation, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information by the executive agency .
Decree Nº 6949:2009	Communication: encompasses languages, text visualisations, Braille, tactile communication, enlarged characters, accessible devices, as well as simple language, writing and speaking, auditive systems, and digital voice means and augmentative and alternative modes, means and formats of communication, including accessible information and communication technology.
Law Nº 10098:2000 as amended by Law Nº 13146:2015	Communication: an interaction form of citizens that encompasses languages, including the Brazilian Sign Language (Libras), text visualisations, Braille, tactile communication, enlarged characters, accessible devices, as well as simple language, writing and speaking, auditive systems and digital voice means and augmentative and alternative modes, means and formats of communication, including accessible information and communication technology.
Directive (EU) 2016/2102	accessibility (in a digital context): the principles and techniques to be followed in the design, development, maintenance, and updating of websites and mobile applications in order to make their content more accessible to users, especially persons with disabilities.

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