

Roadmap to inclusive Artificial Intelligence for persons with intellectual disability

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Abstract: The rapid evolution of Artificial Intelligence (AI) poses significant opportunities and challenges for historically discriminated groups, such as persons with intellectual disabilities. This article proposes a conceptual framework that enables an inclusive and accessible approach to designing generative AI systems. Based on an exhaustive review of legislative, socio-health, and technological sources, key concepts such as disability, accessibility, and usability are defined and related, with intellectual disability serving as the central objective of this work. The need to apply principles of Universal Design (UD) and User-Centred Design (UCD) is highlighted to ensure products, environments, and services that are understandable, usable, and customisable. Finally, specific challenges are identified in the development of generative AI tools in Spain for persons with intellectual disabilities, and specific recommendations are proposed to promote inclusive AI for all.

Keywords: person with disabilities, disability, intellectual disability, inclusion, accessibility, artificial intelligence, Universal Design, User-Centred Design.

1. Introduction

The research and development of products, environments, and services based on Artificial Intelligence (AI) are currently experiencing a significant increase. There is a danger that these advances will increase the access gap for groups that have historically been discriminated against, such as persons with intellectual disabilities. To reduce this gap, it is essential to consider these persons' needs, capabilities, and aspirations from the earliest stages of AI solution design and development. With this objective, four universities (Universidad Carlos III de Madrid, Universidad Complutense de Madrid, Universidad Nacional de Educación a Distancia and Universitat Politècnica de Catalunya) have joined forces in a common project: HumanAI. The HumanAI project (Human-Centred AI: Towards Accessible and Personalised Language Models) aims to develop generative AI tools in Spain, specifically designed for persons with intellectual disabilities.

To advance within the project, it is essential from the beginning to establish a shared conceptual framework that clarifies and relates the key concepts involved. Although these concepts converge

on a common approach, they come from diverse contexts (legislative, technical, and socio-health), which require systematic integration.

This article proposes an analytic structure focused on two principal axes: the person (the user of AI-based systems) and the action or service (that AI-based systems offer to the user). From there, two fundamental dimensions are addressed: disability (as a characteristic of the person) and accessibility (as a quality of the action or service), while also considering the role of legislation, technical standards, and users' own experiences. These contributions should be understood as complementary, with interactions analogous to those proposed in the index for inclusion (Booth & Ainscow, 2002), reflecting the three basic dimensions: cultural, political, and practical.

The aim of this article is therefore to provide a framework to guide the design of more inclusive, useful, and understandable AI systems for all persons, including those with intellectual disabilities. To this end, the following sections will define and relate the concepts introduced, starting with the methodology used for writing this article (Section 2). Section 3 defines the key concepts related to persons with disabilities (fundamentals, accessibility and regulations), and Section 4 specifies the use case of Artificial Intelligence applied to products, environments and services. Finally, Section 5 presents the conclusions of the work and a compilation of key recommendations.

2. Methodology

The main objective of this research is to identify the challenges in developing accessible and inclusive Artificial Intelligence from the perspective of persons with intellectual disabilities based on a literature review. To this end, it is necessary to compile the main reference documents in the field of persons with intellectual disabilities and Artificial Intelligence.

The bibliographic review is carried out based on the following criteria:

- Analyse the concepts of "person with disabilities", "accessibility", "Universal Design", "User-Centred Design", "Information and Communication Technologies", and "Artificial Intelligence", using them simultaneously as keywords in the bibliographic search.
- To focus the review on the legislative, socio-health and technological fields in Spain.
- Consider references of national and international scope.
- If there are different versions or multiple modifications in successive documents, the most recent will be considered.

The primary documentary sources include: in the legislative field, the United Nations (UN), the European Union (EU), and the Government of Spain (through the official national gazette, BOE – Boletín Oficial del Estado); in the social and health field, the World Health Organization (WHO), and the American Psychiatric Association (APA); in the technological field, the European Telecommunications Standards Institute (ETSI), the Spanish Association for Standardization and Certification (AENOR), and the World Wide Web Consortium (W3C). Sources from the associative movement have not been included, as we consider that the analysed sources incorporate their perspective.

Based on this documentation, a conceptual analysis has been conducted to identify, define, and relate key terms concerning intellectual disability and accessibility. The result is a structured proposal of fundamental concepts, intended to serve as a framework in the design of inclusive

AI-based technologies. The analysis is intended for development teams working on AI-based products, environments, and services for persons with intellectual disabilities.

Although we aimed to minimise bias or interpretation by including direct quotations from the original Spanish texts, the act of translating them into English for clarity may have affected the precision or impact of their meaning. Therefore, readers are encouraged to consult the original texts, as cited in the corresponding bibliographic references.

3. Fundamentals

This section defines the key concepts in the field of persons with disabilities. Based on the analysis of the meaning and evolution of the terms presented, a network of conceptual relationships has been established to help understand their interaction in the development of inclusive technologies. The analysis starts by including the user at the centre of the design. From there, the evolution of the concept of disability is traced, which has shifted from an exclusively health-based perspective to a broader one that also incorporates social and technological dimensions. Intellectual disability, the central focus of this work, is explored in depth, followed by an examination of how persons interact with systems. Finally, emphasis is placed on the technical standards that define the essential elements for ensuring the proper functioning of AI-based products, environments, and services, some of which have already become established standards.

3.1. The person with a disability

The starting point of this analysis is the person as a central element to understand the concepts related to disability. Addressing the term "disability" requires examining it in its broadest sense, considering not only its health dimension, but also the social, legislative and technological aspects that surround it. Understanding what it means to live with a disability implies recognising the barriers faced by persons with disabilities and considering the principles of equal opportunities, autonomy and inclusion as fundamental elements in designing truly accessible and inclusive technologies.

3.1.1. Disability

Until 2001, the concept of disability did not exist in its current form. Disabilities were strictly considered within the health field, and their scope of action could be found in the *International Statistical Classification of Diseases and Related Health Problems, ICD-10* (WHO, 1992) of the World Health Organisation (WHO).

In fact, the concept of disability was consolidated internationally because of its incorporation into the *International Classification of Functioning, Disability and Health (ICF)* by the WHO in 2001 (WHO, 2001). A significant advance was achieved by integrating the social and health spheres and conceiving disability as a situation affecting persons, rather than as part of a disease. Therefore, both ICDs and ICFs are complementary since then until today, with the latest version of the ICD being revision 11, ICD-11 (WHO, 2023). The ICF approaches the concept of disability by addressing three interrelated aspects: the deficiency of a bodily structure or function (health domain) limits a person's daily activities (individual level) and restricts this person's participation in society (social level).

The current framework on disability is based on the *United Nations Convention on the Rights of Persons with Disabilities*, adopted in New York on 13 December 2006, CRPD (UN, 2006). This convention lays the foundations for the principles and rights of persons with disabilities:

- "The principles of the present Convention shall be:*
- (a) Respect for inherent dignity, individual autonomy including the freedom to make one's own choices, and independence of persons;*
 - (b) Non-discrimination;*
 - (c) Full and effective participation and inclusion in society;*
 - (d) Respect for difference and acceptance of persons with disabilities as part of human diversity and humanity;*
 - (e) Equality of opportunity;*
 - (f) Accessibility;*
 - (g) Equality between men and women;*
 - (h) Respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities."*

In Spain, the rights of persons with disabilities were ratified through the *Instrument of Ratification of the Convention on the Rights of Persons with Disabilities*, signed in New York on 13 December 2006 (BOE, 2008). This entails a commitment to ensure and promote the whole exercise of all human rights and fundamental freedoms of persons with disabilities, without any discrimination based on disability.

The concept of disability, as it is currently understood, is defined in Royal Legislative Decree 1/2013, of 29 November, which approves the *Recast Text of the General Law on the Rights of Persons with Disabilities and their Social Inclusion*, RDL-1/2013 (BOE, 2013):

"Disability is a situation that results from the interaction between people with foreseeably permanent impairments and any type of barriers that limit or prevent their full and effective participation in society, on equal terms with others."

This situation, whether temporary or permanent, reinforces the need to promote the autonomy of persons with disabilities. The concept of personal autonomy, inspired by the Independent Living Movement, which emerged in the United States in the 60s, was incorporated into the Spanish legal framework, specifically in RDL-1/2013 (BOE, 2013):

"Persons with disabilities have the right to free decision-making, for which information and consent must be made in appropriate formats and in accordance with personal circumstances, following the rules set by the principle of universal design or design for all, so that they are accessible and understandable to them."

The concept of equal opportunity is one of the pillars underlying the concept of disability. In the *CRPD* (UN, 2006), it is established as one of the general principles of the Convention, coming from the social context. RDL-1/2013 (BOE, 2013) provides the current legal definition of the term:

"Equality of opportunity: means the absence of any discrimination, direct or indirect, on the ground of or based on disability, including any distinction, exclusion or restriction which has the purpose or effect of impeding or rendering ineffective the recognition, enjoyment or exercise on an equal basis by persons with disabilities of all human rights and fundamental

freedom the political sphere, economic, social, labour, cultural, civil or other types of work. Likewise, equal opportunities are understood as the adoption of positive action measures."

Analogous to equal opportunities, social inclusion is one of the general principles of the *CRPD* (UN, 2006). Both contribute to the social character of the concept of disability in a complementary manner. Similarly, RDL-1/2013 (BOE, 2013) defines the term as follows:

"Social inclusion: is the principle by virtue of which society promotes shared values aimed at the common good and social cohesion, allowing all persons with disabilities to have the opportunities and resources necessary to participate fully in political, economic, social, educational, labour and cultural life, and to enjoy living conditions on an equal basis with others."

The term "social inclusion" replaces "social integration", as used in *Law 13/1982, of 7 April, on the social integration of the disabled* (BOE, 1982). This terminological change reflects a significant evolution in the cultural and conceptual approach to persons with disabilities. The substitution is not merely lexical: it responds to social advances that have, in turn, influenced the legislative level. There is a shift from a model focused on incorporating persons into the existing system (integrating) to one that promotes their full participation on equal terms (including). This paradigm shift is essential to guarantee a truly inclusive society.

3.1.2. Persons with disabilities

Based on the general definition of disability, RDL-1/2013 (BOE, 2013) specifies who is considered a person with disabilities:

"Persons with disabilities are those who have physical, mental, intellectual or sensory deficiencies, foreseeably permanent, which, when interacting with various barriers, may prevent their full and effective participation in society, on equal terms with others."

In addition, this definition introduces a quantitative criterion to determine who can benefit from the rights and benefits provided by law. Specifically, the following are considered persons with disabilities, for legal purposes:

"... for the purposes of this law, persons with disabilities shall be considered to be those who have been recognized as having a degree of disability equal to or greater than 33 per cent."

The term "person with disabilities" is included in the current legal framework, replacing the obsolete terms "disabled" and "handicapped" established in *Law 13/1982, of 7 April, on the social integration of persons with disabilities* (BOE, 1982). This change reflects an important advance in the way of understanding disability, focusing the term on the person rather than their limitations. The order of the terms, with "person" preceding "disability", highlights this perspective focused on individual rights and dignity. Note the relevance of the noun "person" in the first place, and the adjective "disability" in the second place.

In this context, it is important to note that the term "functional diversity", although used in some associative and informative environments, is not formally recognised in the legislative framework. Its broad scope, which encompasses aspects such as gender, culture, food, or social position, makes it a challenging concept to define for the implementation of specific policies. For this reason, in the legal and technical frameworks, the name "person with disability" is maintained as a clear and shared reference at the international level.

The determination of the degree of disability is officially regulated by Royal Decree 888/2022, of 18 October, which establishes the procedure for recognising, declaring, and qualifying the degree of disability, RD 888/2022, (BOE, 2022). This decree is based on the principles of the *International Classification of Functioning, Disability, and Health (ICF)* and incorporates a social perspective into the evaluation process. To do this, four scales are applied that analyse different dimensions of the person's situation:

- Body impairment: assessed using the Scale of Body Functions and Structures or Global Impairment of the Person.
- Limitation in activity: measured with the Scale of Assessment of Abilities or Limitations in Activity.
- Participation restriction: collected through the Performance Evaluation Scale or Participation Restrictions.
- Environmental contextual factors: analysed using the Scale for the Assessment of Contextual Factors or Environmental Barriers.

The information obtained from these four scales is synthesised in two global and complementary indicators, the profile of functioning and disability and the final degree of disability of the person:

'The global dimension of the person's functioning problem will finally be represented by a "Final Degree of Disability of the Person" and by a "Global Profile of Functioning and Disability".'

The global profile of functioning and disability offers a simplified view of the person's disability situation, including the origin of the disability and its level of incidence. This profile has a qualitative character and serves as a general orientation. The global profile of functioning and disability also includes information on the type of impairment that gives rise to the disability. RD-888/2022 (BOE, 2022), following the recommendations of the ICF (WHO, 2001) and ICD-11 (WHO, 2023), establishes specific terminology to identify these deficiencies. It is important to note that a person may have more than one impairment that contributes to their disability status. When there are multiple relevant impairments -for example, an intellectual impairment together with a sensory or physical impairment- the concept of multiple disabilities applies. This term suggests that it is not a single cause, but rather a combination of factors that collectively pose barriers to persons with disabilities.

On the other hand, the final degree of disability given in Spain is a quantitative value that is calculated from the four scales described above. This degree is expressed as a percentage, which can range from 0% (minimum affectation) to 100% (maximum affectation) and provides an official recognition to the user.

Both indicators complement each other: the profile qualitatively describes the person's situation, while the degree allows it to be quantified. To facilitate interpretation, the percentages are grouped into five levels: null (0-4%), mild (5-24%), moderate (25-49%), severe (50-95%), and total (96-100%). It is essential to note that this assessment is based on the person's ability to perform daily activities, as reflected in the ICF. Additionally, the qualitative values of the profile may vary depending on the scope of evaluation, allowing for some flexibility in its representation.

The European Union incorporates mechanisms for the standardisation and homologation of legislation in its member states in the field of persons with disabilities. To this end, it has established a strategy on the rights of persons with disabilities for 2021-2030 (EU, 2021; AccessibleEU-2, 2023).

3.1.3. Intellectual disability

This section focuses on defining Intellectual Disability (ID) as one of the specific types of "foreseeably permanent impairments" mentioned in the general definition of disability in RDL-1/2013 (BOE, 2013), presented in the previous section.

The procedure for recognising and assessing this disability, including the degree and profile of disability, is detailed in RD-888/2022 (BOE, 2022), which integrates criteria of the American Association on Intellectual and Developmental Disabilities (AAIDD) with the general criteria of the ICD and the ICF on disability.

From a health perspective, the ICD-11 (WHO, 2023) categorises aspects related to impairments in body structures and functions associated with intellectual disability under the category of Intellectual Developmental Disorders (6A00). It is relevant to note that the ICD-11 has updated its terminology with respect to the ICD-10, explicitly using the term "intellectual" and leaving aside the term "cognitive" that was previously associated with the term "intellectual".

The ICF (WHO, 2001) incorporates Intellectual functions (category b117) in the section on mental functions and addresses the following concepts:

"General mental functions, required to understand and constructively integrate the various mental functions, including all cognitive functions and their development over the life span. Inclusions: functions of intellectual growth; intellectual retardation, mental retardation, dementia Exclusions: memory functions (b144); thought functions (b160); higher-level cognitive functions (b164)."

In turn, the AAIDD defines the concept of intellectual disability in the *Diagnostic and Statistical Manual of Mental Disorders, fifth edition, DSM-5* (AAIDD, 2022). It is framed within the intellectual development disorder and proposes the following concepts:

"Intellectual developmental disorder is characterised by deficits in general mental abilities, such as reasoning, problem solving, planning, abstract thinking, judgment, academic learning, and learning from experience. The deficits result in impairments of adaptive functioning, such that the individual fails to meet standards of personal independence and social responsibility in one or more aspects of daily life, including communication, social participation, academic or occupational functioning, and personal independence at home or in community settings."

It should be noted that the formulation of this definition articulates the socio-health aspects related to disability, beyond the purely health aspects that can be observed in the ICD-11. The basic factor traditionally considered to establish intellectual deficiencies has been IQ (comprehension), while communication and social participation are currently considered. For all these reasons, RD-888/2022 (BOE, 2022) assumes the term Intellectual Disability (ID); it is incorporated into the qualitative profile through borderline intellectual capacity, mild ID, moderate ID, severe ID, and profound ID; and formalises it synthetically as follows:

"A disability characterised by significant limitations in intellectual functioning and adaptive behaviour that manifests itself in conceptual, social, and practical adaptive skills"

3.2. Accessibility

For products, environments, and services to be truly inclusive, it is not enough to focus solely on the person in their design. It is also necessary to pay attention to how the person interacts with them and the experience they will have. This section discusses the key principles that should guide the design, development, and use of these elements to ensure equal access and opportunity.

Two major philosophies offer complementary solutions to this challenge. While Universal Design focuses on the end-user's experience of products, environments, and services, Universal Accessibility focuses on their actual implementation, reinforcing the idea of access for all. Difficulties tend to emerge from the interaction between these two perspectives. To solve them, the priority must be placed on adapting products, environments, and services rather than on adapting persons to them.

Through concepts such as Universal Design, Universal Accessibility, Cognitive Accessibility, Infoaccessibility and Usability, a comprehensive approach is proposed, one that places user experience at the centre, from planning to implementation. These principles are essential for transforming everyday actions into real opportunities for participation.

Spanish Royal Decree 193/2023, of 21 March, which regulates the basic conditions of accessibility and non-discrimination for persons with disabilities in accessing and using goods and services available to the public (BOE, 2023), currently legislates this aspect based on the concepts described below.

3.2.1. Universal Design

Once a product, environment or service is already in use, it is costly to make the necessary changes to ensure equal opportunities and inclusion for its users. Therefore, it is essential to adopt a user-centred design approach from the outset, one that considers users' real needs and prevents the creation of barriers to use. This approach represents a profound shift in the way we think about design: it is no longer just about creating functional solutions but about ensuring that they are accessible and non-discriminatory for all users.

The *Convention on the Rights of Persons with Disabilities (CRPD)* (UN, 2006) was a great step forward in defining the concept of Universal Design:

"Universal design means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialised design. Universal design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed."

Its definition highlights two key ideas: first, it describes what this approach consists of; second, it clarifies that although the goal is to create solutions accessible to everyone, specific adaptations will still be necessary for persons in extreme situations.

Subsequently, RDL-1/2013 (BOE, 2013) recast and refined this definition, updating some key terms. It shifted from talking about "technology" to "product", from "help" to "support", and replaced "universal" with the more inclusive expression "for all persons". These changes reflect a greater focus on personal autonomy and independent living, reinforcing the idea that design should always put persons first:

"Universal design or design for all: it is the activity by which environments, processes, goods, products, services, objects, instruments, programs, devices

or tools are conceived or projected from the beginning, and whenever possible, in such a way that they can be used by all people, to the greatest extent possible, without the need for adaptation or specialised design. 'Universal design or design for all' shall not exclude assistive products for particular groups of persons with disabilities, when they need it."

This approach has influenced numerous inclusive design models and practices that are now considered benchmarks, having incorporated its core conceptual principles. On one hand, methodologies such as User-Centred Design (Norman & Draper, 1986), Emotional Design (Norman, 2004) or Design Thinking (Brown, 2008) stand out by structuring the design process around placing the person at the centre. On the other hand, key principles and frameworks, such as the Principles of Universal Design (CUD, 1997) and User Experience (Norman & Nielsen, 1998), provide criteria and perspectives for creating more accessible, useful, and satisfying products.

3.2.2. Universal Accessibility

The concept of accessibility has evolved significantly, moving from a narrow focus on "availability of use" to a broader emphasis on "interaction in use". In the WHO's *International Classification of Functioning, Disability and Health (ICF)* (WHO, 2001), accessibility is recognised as a fundamental requirement of the environmental factors (physical, social and attitudinal) that affect persons' lives. Although the ICF does not provide a formal definition, it emphasises the importance of having available resources to facilitate participation.

The CRPD (UN, 2006) incorporates accessibility as one of its general principles. But it is not formally defined, and its scope is not evident. In the article on accessibility, there is an explicit reference to "access" for persons, and in other articles to "accessibility" of services. This uncertainty remains unresolved in the document General Comment No. 2 of the *United Nations Convention on the Rights of Persons with Disabilities* (UN, 2014) and, therefore, is open to debate.

The formal definition of accessibility is materialised in RDL-1/2013 (BOE, 2013), where the concept of universal accessibility is introduced to underline its integral scope:

"Universal accessibility: it is the condition that environments, processes, goods, products and services, as well as objects, instruments, tools and devices must meet in order to be understandable, usable and practicable by all people in conditions of safety and comfort and most autonomously and naturally possible."

Note that the concept of accessibility provides a characteristic to products, environments and services, while the concept of disability provides a characteristic to persons. From the interaction between persons and products, environments and services arises the concept of accessibility. Therefore, the lack of accessibility can lead to the concept of disability in persons. In addition, the philosophy of Universal Design is assumed to avoid this. Moreover, in any case, it is complemented using assistive products by persons with disabilities.

In 2019, the EU launched Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on accessibility requirements for products and services, DEU-2019/882 (EU, 2019). This directive aims to contribute to the proper functioning of the internal market by harmonising the laws, regulations, and administrative provisions of the Member States regarding the accessibility requirements for products and services. In Spain, it is ratified by Royal Decree 193/2023, of 21 March, which regulates the basic conditions of accessibility and non-

discrimination for persons with disabilities in accessing and using goods and services available to the public, as per RD-193/2023 (BOE, 2023).

"Public administrations shall ensure respect for the right to equal opportunities and non-discrimination of persons with disabilities in accessing and using goods and services available to the public, and any type of discrimination on the grounds of or based on disability in this area shall be prohibited, in the terms provided for in the Consolidated Text of the General Law on the Rights of Persons with Disabilities and their social inclusion."

Truly universal accessibility is a highly honourable social objective, but it is very difficult to achieve. For this reason, the development of "reasonable accommodations" that achieve progress in terms of non-discrimination is contemplated. They refer, therefore, to modifications or adaptations that can be made to products, environments and services to improve the level of accessibility and ensure greater inclusion of all potential users. The term "reasonable" refers precisely to the fact that these adaptations should not be disproportionate either in terms of cost or the resources required for their implementation; however, they are essential to eliminate barriers that prevent the full participation of all persons with disabilities.

3.2.3. Cognitive accessibility

Among the characteristics encompassed by the concept of universal accessibility, those related to understanding, communication and interaction can be grouped under the category of cognition. RDL-1/2013 (BOE, 2013) establishes this in the following text:

"Universal accessibility includes cognitive accessibility to allow easy understanding, communication and interaction for all people. Cognitive accessibility is deployed and made effective through easy reading, alternative and augmentative communication systems, pictograms and other human and technological means available for this purpose."

These characteristics, encompassed by cognitive accessibility, are useful for all persons; necessary to varying degrees for persons with different disabilities; and essential for those with intellectual disabilities.

3.2.4. Infoaccessibility

The term "accessibility" can take on different nuances depending on the context in which it is used, whether referring to disability or relating to different types of products, environments, or services. When applied to the field of Information and Communication Technologies (ICT), the dimension of understanding, communication and interaction, which constitutes the core of these technologies, becomes particularly relevant. In this context, accessibility is given specific names such as infoaccessibility, web accessibility or ICT accessibility. All of them refer to the ability of digital systems to be used by all persons, including those with different types of disabilities. It should be noted that both infoaccessibility and cognitive accessibility share fundamental principles and common objectives: to eliminate barriers, facilitate understanding, ease of use, and ensure full participation in digital environments. In the case of cognitive accessibility, ICTs can incorporate strategies such as language simplification, the use of visual aids, or guided navigation, thereby facilitating access to information and digital services for persons with comprehension or processing difficulties.

Directive (EU) 2016/2102 of the European Parliament and of the Council on the accessibility of websites and applications for mobile devices of public sector bodies, DEU-2016/2102 (EU, 2016), stresses the need to guarantee and standardise the criteria for infoaccessibility. It states that:

"Member States shall ensure that public sector bodies take the necessary measures to make their websites and mobile applications more accessible by making them perceivable, operable, understandable and robust."

Spain incorporated this directive through RD-1112/2018 (BOE 2018), which establishes the objective of ensuring that public sector websites and applications comply with digital accessibility requirements:

"This royal decree aims to guarantee the accessibility requirements of websites and applications for mobile devices of public sector bodies."

Both the directive and the royal decree are implicitly incorporated into the subsequent regulations of the DEU-2019/882 (EU, 2019) and RD-193/2023 (BOE, 2023), also known as the universal accessibility law in Spain. These regulations reinforce the regulatory commitment to digital accessibility, extending its application beyond the public sector. A key aspect of this legislation is that it refers to specific technical standards to detail the specific requirements that ICT products and services must meet. In this sense, the regulatory reference is the European standard EN 301 549 V3.2.1 (2021-03), *Accessibility requirements for ICT products and services* (ETSI, 2021), and its Spanish counterpart, UNE-EN 301549 V.1.1.2:2015 *Accessibility requirements for ICT products and services applicable to public procurement in Europe* (UNE, 2022). These standards establish the technical criteria that must be met in the design, development and acquisition of accessible technologies and are based on the W3C Web Content Accessibility Guidelines (WCAG), which constitute the international benchmark for the accessible design of websites and digital content.

3.2.5. Usability

From the ICT field, there is a concept closely related to accessibility, but that should not be confused with it: usability. Usability is an indicator that considers the ease of use of a product, environment or service and the satisfaction of the user. Consequently, when an element is not usable, it is also not accessible. However, both concepts do not have the same scope, as accessibility is suitable for all persons, without any exclusion. The UNE-EN ISO 9241-11:2018 standard, *Ergonomics of human-system interaction. Part 11: Usability. Definitions and concepts*. (UNE 2018) defines it in this way:

"The degree to which specific users can use a product to achieve a goal effectively, efficiently, and satisfactorily in a specific use context."

The characteristic of usability is analogous to practicability, a term generally used in the field of universal accessibility. In both cases, the variable to be analysed is interaction. In practice, usability allows for the assessment of the function to be incorporated alongside interaction, making accessibility and usability complementary characteristics.

Usability measures how quickly and easily a group of persons can perform specific tasks using a particular product, environment, or service. Therefore, it is the users, not the designers or developers, who determine when it is simple and effective to use. Usability presupposes that the product, environment or service has been developed with the user in mind to meet their needs, and that the developer possesses extensive knowledge of the context and modes of use of the product or service.

User experience is therefore a key concept related to usability. It encompasses the range of factors that influence a person's sensations or reactions when using a product, environment, or service in a specific context. In the field of ICT, this includes various aspects such as the user's interaction with screen elements (menus, tabs, buttons), the activation of images, videos or sounds, colours, the contrast between text and background, font types, the number of clicks required to reach desired information, and the dynamic or unexpected appearance of components and drop-down menus on web pages.

3.3. The standard

Just as the spelling, grammatical, semantic and lexical rules of a language must be respected in creating a correct sentence, the corresponding rules must also be considered in the development of products, environments and services. Technical standards should be understood as guides to good practice that define the essential elements required to ensure the proper functioning of products, environments and services. When sufficient consensus is reached, they become standards, and compliance may become mandatory if required by law.

Many countries already have a legislative framework that ensures equitable access to information systems for users with disabilities. In Europe, all countries are required to transpose directives into their national legislation. To ensure coherence and effective standardisation in the field of accessibility, specific reference frameworks are established in the field of accessibility (AccessibleEU-1, 2023).

3.3.1. The user experience

As previously explained, the person should be at the centre of accessibility and inclusion, with the aim being to ensure the best possible interaction when using a product, environment, or service. To achieve this, it is essential to incorporate the user experience at all stages of a product, environment, or service's life cycle. In this context, the User-Centred Design (UCD) methodology, included in the standard UNE-EN ISO 9241-210:2019. Ergonomics of human-system interaction - Part 210: Human operator-centred design for interactive systems (UNE, 2019). This standard defines UCD as follows:

"An approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques."

The UCD methodology is characterised by the active involvement of users, a clear understanding of their needs and tasks, an appropriate allocation of functions between users and technology, the iterative development of design solutions, and a multidisciplinary approach to design.

3.3.2. The WCAG

The Web Content Accessibility Guidelines (WCAG) are the most important international effort to establish a standard for accessible design in ICT and to provide guidance on accessibility for persons with disabilities. These guidelines were originally developed for web environments and have gradually evolved to encompass all ICT products, environments, and services. WCAGs are based on four fundamental principles (W3C, 2024).

" Perceivable - Information and user interface components must be presentable to users in ways they can perceive."

Operable - User interface components and navigation must be operable.

Understandable - Information and the operation of user interface must be

*Robust - Content must be robust enough that it can be interpreted reliably
by a wide variety of user agents, including assistive technologies.”*

Since their origins in 1999 in the Web Accessibility Initiative (WAI) of the World Wide Web Consortium (W3C), these guidelines have been progressively refined through successive versions, from 1.0 to the current 2.2. Since 2014, they have been formalised as standards through technical standards (ETSI, 2021; UNE, 2024). In September 2018, Royal Decree 1112/2018 of 7 September 2018 on the accessibility of websites and mobile applications in the public sector (BOE, 2018) came into force, transposing European Directive 2016/21022 (EU, 2016) into Spanish law.

The guidelines outlined in the WCAG are categorised into three levels: A, AA and AAA. Level A guidelines encompass the most basic requirements, enabling a minimum degree of accessibility to be achieved. Level AA includes features necessary to achieve an acceptable level of accessibility, while level AAA comprises the most stringent and comprehensive accessibility criteria. When all the characteristics of a level have been met, the product, environment, or service is considered to comply with the respective A, AA, or AAA certification. Currently, it is mandatory to pass an AA certification in public sector products, environments and services (BOE, 2018).

3.3.3. The WAI-ARIA

The WAI Accessible Rich Internet Applications Suite (WAI-ARIA) define the means to incorporate semantic information into ICT content and applications (W3C, 2023). Assistive products utilise this information to facilitate interaction between persons with disabilities and ICT products, environments, and services. These guidelines are complementary to WCAG, providing an ontology of roles, states, and properties that define interface elements and controls developed with Ajax, HTML, JavaScript, and their related technologies. It allows you to define what role or function an item has and indicate its status and properties, which can be dynamically modified so that assistive products (such as screen readers) can announce changes that occur dynamically (e.g., a drop-down list that opens and shows all the options to choose from).

3.3.4. The COGA

The Cognitive Accessibility Guidance (COGA) focuses its scope of action on persons with intellectual disabilities and learning disorders (W3C, 2021). These guidelines articulate their recommendations beyond the usability of the interface, considering formal aspects of the design, context, structure, language and other applicable factors.

The COGA guidelines identify a set of key points:

- Help users understand what things are and how to use them, find what they need, avoid mistakes, and focus.
- Incorporate clear content, such as text, images and multimedia, into systems and processes that rely on memory, while also providing adaptation, personalisation, help, and support.
- Involve persons with intellectual disabilities and learning disorders in the process of researching, designing, and implementing products, environments, and services.

3.3.5. Easy reading

Effective communication is one of the key factors in the interaction of persons with intellectual disabilities. Within the framework of cognitive accessibility, the UNE 153101:2018 EX. Easy to read. Guidelines and recommendations for the elaboration of documents (UNE-1, 2018) defines and formalises the concept of easy-to-read:

"Method that includes a set of guidelines and recommendations related to the writing of texts, the design/layout of documents and the validation of their comprehensibility, aimed at making information accessible to people with reading comprehension difficulties."

Easy reading is included in RD-1112/2018 (BOE, 2013) as one of the necessary mechanisms to achieve cognitive accessibility:

"Establishing that cognitive accessibility is deployed and made effective through easy reading, alternative and augmentative communication systems, pictograms and other human and technological means available for this purpose."

3.3.6. Products and support

Legislation related to persons with disabilities (BOE, 2008; BOE, 2013; BOE, 2018; and BOE, 2023) highlights the use of products and assistive devices as complementary tools to achieve accessibility in products, environments, and services.

Although the products and assistive devices must comply with their specific regulations, it is important to understand how they are structured and defined. This understanding helps consider their interaction with the products, environments and services they complement, as well as the requirements arising from the application of relevant standards.

The UNE-EN ISO 9999:2023 Assistive Products - Classification and terminology (UNE, 2023) provides this information and offers a comprehensive definition of assistive products in its broadest sense:

"Product that optimises a person's functioning and reduces their disability... Supporting products include devices, instruments, equipment and software."

4. Considerations for an inclusive generative Artificial Intelligence

This section outlines the fundamental concepts introduced in the previous section, applying them specifically to the use case of Artificial Intelligence in products, environments, and services. If the concept of service is understood in its broadest sense, encompassing both products and environments, then two key aspects emerge as essential: the use of the service and the understanding of how it is used. In RD 193/2023 (BOE, 2023), the concepts of products (goods) and services are defined as follows:

"(b) Goods: Items, articles and products, in particular goods, particularly those whose provision does not constitute a service, and which are made available to the public in the ordinary course of an open market."

"(c) Services: Publicly available services provided by a natural or legal person, whether or not there is remuneration for them."

In turn, the concept of Artificial Intelligence can be defined according to the European Commission's Independent High-Level Expert Group on Artificial Intelligence in the document "A definition of AI: main capabilities and disciplines" (EU-1, 2019) as follows:

"Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals.

AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications). "

Regulation 2024/1689 of the European Parliament and of the Council of 13 June 2024 (EU, 2024) specifies the characteristics to be considered in the field of Artificial Intelligence. AI systems must include, at a minimum, a user interface and an AI model. The AI model within the system determines its scope of action. As stated in the regulation:

"The notion of general-purpose AI models should be clearly defined and set apart from the notion of AI systems to enable legal certainty. The definition should be based on the key functional characteristics of a general-purpose AI model, in particular the generality and the capability to competently perform a wide range of distinct tasks. These models are typically trained on large amounts of data, through various methods, such as self-supervised, unsupervised or reinforcement learning."

These models have evolved to reach the ability to dynamically generate content during interactions with users; these are known as generative AI models:

"Large generative AI models are a typical example for a general-purpose AI model, given that they allow for flexible generation of content, such as in the form of text, audio, images or video, that can readily accommodate a wide range of distinctive tasks."

From these initial definitions, it is essential to consider the ethical, legal, formal, social, and other relevant dimensions that will shape the resulting systems based on Artificial Intelligence. These considerations should be understood as guiding recommendations for the multidisciplinary teams involved throughout the entire AI lifecycle, including development, deployment, and exploitation.

This section is structured into three subsections. The first focuses on ethics and outlines the fundamental principles and requirements that reliable AI systems, those that respect human rights, must fulfil. The second examines the implications of disability explicitly, identifying the risks of exclusion and the necessary safeguards to guarantee equal opportunities in AI. Finally, the third addresses the specific accessibility requirements that AI-based products, environments and services must satisfy, with special attention to cognitive accessibility and personalisation. This division responds to the need to integrate complementary perspectives to move towards a truly inclusive design.

4.1. From ethics

The European Commission, through the Independent High-Level Expert Group on Artificial Intelligence, in the document *Ethical Guidelines for Trustworthy AI* (EU-2, 2019), proposes a set of considerations on AI. They are based on the concept of AI reliability. In other words, the systems and the persons who make them up prove to be worthy of the trust of their users:

" Trustworthy AI has three components, which should be met throughout the system's entire life cycle: (1) it should be lawful, complying with all applicable laws and regulations (2) it should be ethical, ensuring adherence to ethical principles and values and (3) it should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm. Each component in itself is necessary but not sufficient for the achievement of Trustworthy AI. Ideally, all three components work in harmony and overlap in their operation. If, in practice, tensions arise between these components, society should endeavour to align them."

To this end, reliable AI must comply with the fundamental principles of human rights, and particularly those of persons with disabilities:

" Develop, deploy and use AI systems in a way that adheres to the ethical principles of respect for human autonomy, prevention of harm, fairness and explicability. Acknowledge and address the potential tensions between these principles."

From these, it must incorporate seven requirements necessary to guarantee reliable AI:

" Ensure that the development, deployment and use of AI systems meets the seven key requirements for Trustworthy AI: (1) human agency and oversight, (2) technical robustness and safety, (3) privacy and data governance, (4) transparency, (5) diversity, non-discrimination and fairness, (6) environmental and societal well-being and (7) accountability."

As well as evaluating their performance beyond mere evaluation lists:

" Ensuring Trustworthy AI is not about ticking boxes, but about continuously identifying and implementing requirements, evaluating solutions, ensuring improved outcomes throughout the AI system's lifecycle, and involving stakeholders in this."

4.2. From disability

The 2022 Report of the Special Rapporteur on the Rights of Persons with Disabilities to the United Nations Human Rights Council (UN, 2021) identifies a set of key elements to make AI tools truly inclusive. First, the report identifies a set of legal areas that are particularly sensitive in relation to the use of AI tools:

" The rights and core norms of the Convention on the Rights of Persons with Disabilities form the basic yardsticks by which to assess the risks and opportunities presented by artificial intelligence. The relevant rights and corollary obligations include, among others, privacy, autonomy, independent living, employment, education, health and in particular the overall guarantee of equality and non-discrimination."

AI tools must respect the privacy of persons with disabilities, as any infringement could pose a significant risk of social exclusion:

" Rights to privacy and data protection are fundamental to human dignity. The right to privacy is protected under article 22 of the Convention and article 31 sets out parameters for the protection of disability data and statistics. Data belonging to persons with disabilities refers to the content they create, the information collected about them and what is inferred through algorithms."

Both the algorithms and the data corpora used in the training of AI tools must not contain systemic biases that lead to discrimination against persons with disabilities:

" There is documentary evidence that there is an inherent bias in some facial recognition algorithms against persons with disabilities who were judged untrustworthy because their face did not conform to the standard programmed into the artificial intelligence system."

"Proposed fixes to systemic bias should be treated with caution, as disability inclusion in artificial intelligence requires an understanding of not only the data sets used but also of the decision-making process of the artificial intelligence system to avoid discrimination. "

Competent bodies should be able to assess the risk of AI tools generating discriminatory situations. To this end, the algorithms, data corpora and systems involved in the evaluation process must be accessible:

" Major barriers to transparent artificial intelligence systems include the confidentiality of the code in algorithms and the system itself."

Reasonable adjustments must also be implemented at all stages of research, development, and deployment of AI tools:

" Insist on the obligation of reasonable accommodation in the operation of artificial intelligence systems, including by incorporating reasonable accommodation into artificial intelligence tools."

In addition, the accessibility of AI products, environments and services is the basis for avoiding situations of discrimination and exclusion:

" While artificial intelligence does indeed raise a range of accessibility concerns, the core concern of the Special Rapporteur in the present report is how artificial intelligence tools impact persons with disabilities. Front and centre is the question of equal treatment or discrimination."

Finally, it is essential to incorporate persons with disabilities and their representative organisations in all stages of research and development of AI products, environments and services:

" Owing to the lack of consideration for and involvement of persons with disabilities in the development of artificial intelligence, these systems are creating divisions rather than promoting access and supported environments."

4.3. From accessibility

Ensuring accessibility in products, environments, and services based on generative Artificial Intelligence requires a rigorous application of existing regulatory frameworks and a critical review of their limitations in addressing the new challenges posed by these AI-based systems. The WCAG 2.2 guidelines, at level AA, serve as the primary reference for assessing digital accessibility, establishing minimum requirements in terms of perception, operability, comprehensibility, and robustness of content. These guidelines are complemented by other initiatives such as WAI-ARIA, which incorporate essential semantic information to facilitate interaction with assistive products.

However, in the specific case of intellectual disability, these normative tools are necessary, but not sufficient. The COGA guidelines address this dimension with a more specific approach, aimed at minimising cognitive barriers, facilitating navigation, reducing memory load, promoting language clarity, and providing visual and structural supports. Similarly, the UNE 153101 standard on easy reading provides a set of guidelines for writing, layout and validation of texts aimed at persons with reading comprehension difficulties. Incorporating these principles is essential to ensure that generative AI systems are accessible and usable for persons with intellectual disabilities.

Despite the existence of these recommendations, several recent studies indicate that their implementation in generative AI-based tools remains very limited. An accessibility analysis conducted on 50 generative AI applications (Acosta-Vargas et al., 2024), following WCAG 2.2 criteria, revealed significant problems in all interfaces evaluated. Contrast errors, inappropriate structures, incorrect use of ARIA tags and other technical alerts that directly affect the interaction were detected. Additionally, the content generated by these systems often exhibits a high reading level, understandable only to users with a university education, partly due to the biases present in the training corpora. Added to this is the opacity of the algorithms, which makes it challenging to evaluate and correct these barriers properly.

This lack of transparency is further accentuated by the change in interaction brought about by the emergence of generative AI, which is transforming the way persons interact with technology. Nielsen (2023) refers to this approach as "intent-based specification of results": the user informs the system of their desired outcome, and the AI determines the most effective way to achieve it. This apparent simplification, which can benefit many users, introduces new challenges for those with cognitive difficulties, as algorithms take over part of the control of the interaction. As Weiser (1999) pointed out, technology can become "invisible" in its use; however, this can make it difficult for the end user to understand the system. This is especially problematic when transparency and control are requirements for accessibility.

Likewise, this new form of interaction requires users to learn how to formulate precise instructions (known as prompt engineering). This skill can pose a significant barrier for persons with intellectual disabilities if adequate support is not provided. Moreover, conversational interfaces (whether written or spoken), if not well designed, risk being exclusionary and perpetuating traditional models of digital exclusion.

Moving towards truly accessible generative AI requires an inclusive approach from the very beginning. This implies adopting appropriate methodologies, such as User-Centred Design, which guarantee that solutions are adjusted to the real needs of the collective. Furthermore, the tools used throughout the process must themselves comply with established accessibility requirements.

Studies indicate that persons with intellectual disabilities particularly benefit from systems offering multimodal interaction, combining voice, text, and images, as these channels enhance content comprehension and facilitate the expression of intentions (Roomkham & Sitbon, 2024). Improvement in comprehension occurs primarily through the visualisation of images, then through text-to-speech, and finally, through written text, which also encourages the user's engagement with these tools (Liu et al., 2023). This approach is already recognised in the CRPD (BOE 2008), which advocates the use of alternative and augmentative means of communication:

"Communication' shall include languages, text display, Braille, tactile communication, large print, easily accessible multimedia devices, as well as written language, auditory systems, plain language, digitised voice media and other augmentative or alternative modes, media and formats of communication, including easily accessible information and communication technology."

In summary, achieving effective accessibility in generative AI systems requires: the direct participation of persons with intellectual disabilities; the incorporation of multimodal interaction strategies (text, voice and images); the simplification and progressive adaptation of language; and the possibility of customising communication modes. Additionally, it is essential to ensure that tools used during the design and evaluation process meet accessibility criteria, thereby preventing barriers from being replicated from the earliest stages of development.

Only through this comprehensive approach -combining regulations, participatory methodologies and technical solutions adapted to cognitive diversity- will it be possible to develop truly inclusive generative AI technologies.

5. Conclusions

Moving towards truly inclusive Artificial Intelligence requires a change of approach that places persons with intellectual disabilities at the centre of the design, development and evaluation of these technological systems. This paper proposes a conceptual framework that articulates three complementary dimensions -ethics, disability and accessibility- as fundamental pillars to identify challenges and guide solutions in this area.

Throughout the article, the main concepts necessary to understand the specific needs of this group have been defined, as well as the barriers they face when interacting with generative AI technologies. These concepts, integrated from legislative, socio-health, and technological perspectives, offer a common language for multidisciplinary teams involved in creating accessible products, environments, and services. This framework is especially useful for researchers and developers who are new to this field, as it provides a systematic view of the key elements to be considered to generate truly inclusive technological solutions. The literature review has identified a collection of a set of forty-two key documents, offering comprehensive insight into the context of persons with disabilities and their interactions with ICT products, environments, and services, as well as their engagement with artificial intelligence systems. Among these, seventeen documents pertain to legislation, four to social and health fields, and twenty-one to technology. All of them have maximum relevance, as well as national and international reach.

On this basis, key recommendations have been formulated to help developers of AI-based products, environments, and services appropriately contextualise systems, algorithms, and training corpora to the needs of persons with intellectual disabilities. These recommendations go beyond mere regulatory compliance, emphasising the importance of inclusive methodologies,

multimodal strategies, and a critical assessment of the current limitations inherent in conversational interfaces and generative models.

Ultimately, this work is part of a broader research agenda focused on developing real and sustainable solutions. The HumanAI project (Human-centred Artificial Intelligence: Towards Accessible and Customisable Language Models), funded by the State Research Agency in the 2023 call for Knowledge Generation projects, aligns with this goal. The project seeks to create generative AI tools in Spanish explicitly designed for persons with intellectual disabilities. To achieve this, it adopts a User-Centred Design methodology that actively involves users throughout all phases –from customising language models to designing cognitively accessible interfaces – adhering to a human-in-the-loop approach. This collaborative approach, developed by teams from the Universidad Carlos III de Madrid (UC3M), Universidad Complutense de Madrid (UCM), Universidad Nacional de Educación a Distancia (UNED) and Universitat Politècnica de Catalunya (UPC), will allow empirically validating many of the conceptual proposals formulated here and represents a step forward towards a truly inclusive AI for all.

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