**Accessibility recommendations for Open Educational Resources for people with learning disabilities**

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**Recomendaciones de accesibilidad para recursos educativos abiertos para personas con discapacidades de aprendizaje**

**Resumen:**

Para contribuir a la inclusión cada vez mayor de personas que han estado fuera de la sociedad durante mucho tiempo, es posible construir material didáctico accesible para audiencias específicas, como personas con discapacidades de aprendizaje u otras barreras para el pleno logro de su procesos de aprendizaje, por ejemplo, personas mayores, sordas y con discapacidad visual. Este documento tiene como objetivo contribuir al área de accesibilidad mediante la presentación de un conjunto de recomendaciones para autores de Recursos Educativos Abiertos que no son necesariamente especialistas en TIC, con el fin de ayudar al proceso de proporcionar una mayor accesibilidad para las personas con discapacidades de aprendizaje.

# Accessibility recommendations for Open Educational Resources for people with learning disabilities

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**Abstract.** In order to contribute to the increasing inclusion of people who have been for a long time out of society, it is possible to construct accessible didactic material for specific audiences, such as for people with learning disabilities, or other barriers to the full achievement of their learning processes, for instance, elderly, deaf, and visually impaired people. This paper aims to contribute to the area of accessibility by presenting a set of recommendations for authors of Open Educational Resources that are not necessarily specialists in ICT, in order to help the process of providing more accessibility for people with learning disabilities.

**Keywords:** Learning disabilities, accessibility, open educational resources, universal design for learning.

## 1    Introduction

From the earliest years of life, the human being acquires knowledge through learning. According to [1], learning is a necessary and universal process for the development of culturally organized and particularly human psychological functions. Regarding formal education, it has to be pointed out that access to learning is a right for all, regardless of ones disabilities.

On the other hand, learning disabilities are related to significant difficulties in the acquisition and use of writing, speaking, listening, reading and mathematical problem solving skills [2][3]. Despite concerns about improving the theoretical foundation and attempts to increase the quality of teacher education, there are still high rates of unattended children with learning disabilities.

Many children present specific learning disabilities, such as dyslexia, dysgraphia and dyscalculia. Research by the National Center for Education Statistics (NCES) in the US, indicates that there are 34% of students aged 3 to 21 who have specific learning disability [4]. Schools have the mission of bringing knowledge to each child, with a unique cognitive and genetic profile, maximizing their skills and knowledge. Thus, children with learning disabilities should receive attention that minimizes their disabilities. Therefore, using Universal Design for Learning [5], combined with Information and Communication Technology, seems to be a way to address the issue of exclusion of people with disabilities.

The different modes of learning showed that students have specific needs to make learning effective. The Universal Design for Learning intends to make the school curriculum more flexible to meet specific learning needs of the students, i.e. their skills and knowledge, as well as their experiences. Prioritizing a set of principles intended to provide students with the same opportunities to learn but focusing on the inequalities of the individual in relation to their skills, needs and interests [5]. With technology as an ally, it sets out to adopt the most efficient and appropriate materials and methods to reach all students. The combination of different media in content transmission supports the development of flexible learning content that can meet the different learning needs of students.

Besides, the adoption of Open Educational Resources (OER) brings a whole new scenario of possibilities for adapting already existing content to meet specific requirements [6]. By dwelling on open licenses and formats, OER makes it possible to reduce adoption costs and makes more feasible the process of design and deliver courses that comply with specific accessibility needs.

In this context, the aim of this paper is to present recommendations for the construction of accessible OER for people with learning disabilities, aimed at teachers with or without previous ICT knowledge. When designing accessible OER, it is important to know the students' profile and to establish the limitations arising from learning difficulties.

This paper is structured as follows. Section 2 provides the necessary background for understanding this paper's context: developmental disorders, universal design for learning; accessibility guidelines and related work. Next, in section 3 are the materials and methods. Section 4 provides accessibility recommendations. Finally, in section 5, some final conclusions of this paper are drawn.

## 2        Background

### 2.1        Learning Disabilities

Learning disabilities are relatively common conditions and refers to a heterogeneous group of disorders that manifest as significant difficulties in the acquisition and use of writing, speaking, listening, reading and mathematical problem solving skills [2][3]. According to the International Classification of Diseases (ICD) learning disability is considered a condition of interrupted or incomplete development in cognitive functioning or adaptive behavior in the developmental period [7]. The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition - DSM-5 [8], the main reference in

professional practice and research in this field includes difficulties in writing, reading and calculating, as well as difficulties not specified in a category called Specific learning disorder. The manual classifies the disorder as mild, moderate and severe.

It is noteworthy that the specific learning disorder, according to DSM 5, to be characterized as such, it is necessary to identify one of the symptoms described in the manual and that this symptom persists for at least six months despite possible interventions [8].

These disorders are understood to be intrinsic to the individual, supposedly due to central nervous system dysfunction, there may be accompanying disabilities (e.g. intellectual disabilities, severe emotional disorders, and sensory deficits) and may occur at any time during a person's life. However, extrinsic circumstances arising from an individual's surrounding context, such as cultural differences, inadequate teaching, or the presence of comorbid conditions such as ADHD, can have a strong influence on the diagnosis and progress of learning disabilities [8][9].

In addition to interfering with learning basic skills such as math, reading and / or writing, processing problems can interfere with higher-level skills such as attention, organization, abstract thinking, time planning, long or short-term memory. Learning disabilities can affect an individual's life beyond academics and can impact relationships with family, friends, and the workplace [9].

Many studies have been conducted over the last decades to understand the basis of these neurodevelopmental disorders, leading to the identification of some altered specific neural networks, although there is still no complete understanding of the mechanisms involved [10][11][12].

The lack of consensus on the conceptualization of learning disabilities and the use of different models to identify learning disabilities are pointed as possible reasons for the small number of studies on the effects of the implementation of prevention programs. Even in this scenario, the prevention of learning disabilities is a topic of great relevance in the clinical and educational areas [13].

Even if there is no consensus on the conceptualization as difficulty or disorder, it is important that intervention proposals help reduce the negative impact of poor school performance, social and emotional aspects beyond learning.

## 2.2 Universal Design for Learning

From the concept of Universal Design [14], in the 1980s, used in the educational context, came the concept of Universal Design for Learning (UDL). UDL is a proposal that aims to ensure access to content for all students, regardless of their limitations, so that the goal of education has shifted from knowledge acquisition to student experience.

According to [5], UDL consists of a set of principles that constitute a practical model in order to maximize learning opportunities for all students. These principles are based on neuroscience and the use of media to help educators reach all students by adopting appropriate learning objectives, choosing and developing efficient materials and methods, and building a fair and accurate ways to measure student progress.

In order for students to have access to knowledge, there must be some changes in four aspects of the curriculum: 1) Goals: listing the knowledge and skills necessary for students to reach; 2) Evaluation: monitoring the student's evolution and propose

changes in the proposals whenever necessary; 3) Methods: offering several learning contexts, offering multiple types of learning resources and keeping the student motivated and proactive in the task; 4) Content: they should be in accordance with learning goals. According to the UDL principles, flexibility of curricula occurs through the ability to provide [5]:

- Multiple modes of presentation: it can be reached by providing options for perception, such as information display customization options, providing hearing and visual alternatives; offering options for language and symbols, and giving options for understanding, i.e., use strategies related to activating or providing background knowledge; highlight interactions, essentials, main ideas and connections.
- Action and expression: use strategies to diversify response methods and path; optimize access to tools and assistive technology; use strategies to diversify response methods and path; optimize access to tools and assistive technology; offer options for executive functions, such as: supporting development planning and strategy; options that facilitate information and resource management.
- Engagement: Provide options to encourage student interest by maximizing relevance, value and authenticity and minimizing insecurity and anxiety; provide options to sustain effort and persistence, such as: options that vary levels of challenge and support; foster collaboration and a sense of community; provide self-regulation options: use strategies to promote expectations and anticipations that optimize motivation; develop self-assessment and reflection.

Furthermore, the use of technology is crucial to guarantee access to content, as well as to allow students to be more independent and autonomous in academic tasks. Technologies can reduce methodological barriers, providing the same curriculum for all, but with personalized goals, methods, evaluation and content [15].

## 2.3 Accessibility Guidelines

Web accessibility barriers have made it difficult for people with disabilities to navigate the Web. Concerned about these barriers, in 1997, W3C launched the Web Accessibility Initiative (WAI). Implementing accessible web pages has been realized to benefit not only disabled people, but other users, as well as devices such as mobile, which have limited resources. This initiative drafted and published the WCAG 1.0 (Web Content Accessibility Guidelines 1.0) in the late 90's. In order to make web content accessible to anyone, regardless of the device used (desktop, mobile, etc.), WCAG 1.0 defines fourteen general guidelines or principles for an accessible project.

Each of the guidelines is associated with checkpoints that explain how it should be applied, providing links to technical documents with examples for implementing such points. Checkpoints are assigned priority levels, depending on the impact they may have on accessibility [16]. Meeting the recommendations of each priority level interferes with the level of compliance achieved by the website [17]. Priority levels are numbered from 1 to 3, describing as required application requirements, otherwise it will be impossible for one or more groups to access web content; as requirements that should have in the application, otherwise some groups will have difficulty accessing the

content; and as requirements they might have in the application, so that it is easier for some groups to gain access, respectively [16].

WCAG 1.0 was updated in 2008 resulting in the publication of WCAG 2.0 complementing it and being designed to be widely applied to Web technologies. These guidelines are divided into four main topics, which are: perceptible (information and interface components must be presented so that users can capture them); operable (interface and navigation components must be operable); understandable (information and use of the interface must be understandable); robust (content must be robust to be fully interpreted by a wide variety of users) [18].

The last W3C accessibility guidelines update took place in 2018, with the publication of WCAG 2.1, which also does not nullify WCAG. On the contrary it complements it. The WCAG 2.1 goal to improve accessibility guidance for three major groups: users with cognitive or learning disabilities, users with low vision, and users with disabilities on mobile devices [19].

## 2.4    Related Work

When analyzing accessibility issues, it is worth referring to studies related to the design of user-friendly interfaces and research results. American researchers testing Universal Design for Learning (UDL) among people with disabilities using digital platforms noticed that students with various learning deficits are much more involved in learning new messages through UDL platforms. In addition, the same group found that the overall results of the final test were higher with UDL than without such solutions [20]. However, when designing learning support systems for people with deficits, it is worth taking into account the diversity of disabilities as well as the specific characteristics of the learner, which allows to focus on the type of deficits [21].

The way in which a learner engages in a learning process is important to his or her performance. The UDL overcomes the barriers of deficits and reinforces deep learning [22]. It is interesting in this context to recall the results of systematic content analysis. Researchers using this technique to process the available results have drawn some interesting conclusions. Firstly, the availability of e-learning is an urgent need for people with cognitive disabilities. So far, there are still too few analyses focused on cognitive accessibility. Typically, research on e-learning and UDL is focused on specific disorders/diseases rather than on the cognitive functions of the learner.

One of the factors forcing a change in the approach outlined above is the systemic transformations resulting from the evolution of higher education. According to British researchers, the application of UDL has a chance to increase the inclusion effectiveness of dimensions of educational activities. UDL is also a way to implement the strategy of excellence in many institutions dealing with adult education [23]. The metatheoretical results of analyses related to the learning process show the UDL as an intelligent strategy for the implementation of people with disabilities in the information society [24]. However, practitioners designing platforms for people with disabilities draw attention to several important criteria. First, language is becoming a key element. Increasing the effectiveness of the digital learning environment requires the use of transparent language (understood by people with different disabilities). This issue is sometimes

supported by several graphic solutions (diagrams, thought maps, pictograms, etc.). An important element is the design of effective navigation to the platform content. Overloading and underloading with photos or videos can also disrupt the learning process. It is important for the UDL to include summaries and create shortcuts of knowledge and skills [25].

The UDL is a concept with an extensive application. Currently, the literature on the subject shows that the concept works well in various thematic areas that can be combined with the increasingly popular VR and AR technologies [26]. Often, the authors point to the possibility of using UDL in the design of applications, platforms operating not only for a diverse group of students, but also for hardware diversity (including popular mobile devices) [27].

Inclusion has always been one of the main OER premises. Although many discussions [28][29] were centered in the social aspect of inclusion - since granting open access to high-quality learning content would help to break some important socioeconomic barriers to the education, the case for OER as a key point for accessibility has been discussed by many other authors, like [30]. The compliance to the openness principles [31] is a core aspect to guarantee that accessible material is able to be adapted, remixed, revised, repurposed and redistributed, according to the specific learning requirements, especially those related to learning disabilities.

## 3 Materials and Methods

From the DUA, W3C guidelines, OER recommendations, features of people with learning disabilities and the authors' expertise in building accessible material, we propose some recommendations for educators as authors of accessible OER. We divided recommendations into two different perspectives: using an authoring tool to support the technology and recommendations to create accessible OER selecting appropriate media and pedagogical/ instructional resources. A methodological cut was made and taken as target audience for the OER only that people with some learning disability or barrier.

We then generated a list of recommendations for authors of OER for the audience regarding the care they should take to create or use text, video, images, sounds and other resources. These resources should be used with the support of an authoring tool for the generation of accessible teaching courses.

## 4 Recommendations for Authors of Accessible OER for People with Learning Disabilities

The concept of UDL is closely associated with the use of technology; however, UDL is not just the use of technology in education [32]. It is also about pedagogical or instructional practices used by students with or without disabilities.

Thus, to build accessible OER, we can think of two complementary scenarios: the use of technologies to provide facilitators for students (such as screen readers, increase the font size, calculators, speech recognition, speech synthesizers, etc.) and the

instructional and pedagogical practices that teachers should think about to meet the conditions of their students. As a background, all aspects of openness brought by OER must be considered in the authoring process [31].

The work presented by [33] already pointed to the technologies that could be used to help people with learning difficulties. The author cites, for example, Word Processing, Spell Checking, Proofreading Programs, Speech Recognition to minimize Written Language problems; Speech Synthesis, Optical Character Recognition Systems for Reading Problems; Personal Data Managers and Free-Form Databases for Organization and Memory Issues; Talking Calculators for Math Problems.

Table 1 presents a summary of the main difficulties presented by people with learning disabilities and how this is minimized by technological and / or pedagogical resources, based on [32][33] and in the authors' practice in developing accessible digital material.

**Table 1.** Relationship between the difficulties presented by people with learning difficulties and the computational resources (source: authors).

| Difficulties | Technological and pedagogical Resources |
| --- | --- |
| Reading | Screen Reader, small and simpler text, use auxiliary vocabulary, don't use abbreviations |
| Writing | Typing text, spell checker |
| Calculating | Calculator, numeric ruler |
| Attention | Use more than one media resource (image, video, text, sound), use feedback frequently |
| Time planning | Don't use time in the activities or giving more time to do the activities |
| Long or short-term memory | Videos/ imagens/ links |
| Organization | Index of contents |
| Cognitive problems | Use of alternative texts in images and links, use of simpler texts, use of videos and other multimedia resources to complement the understanding of texts, tips and glossary for less common words. |

Some of the features presented in Table 1 may be provided through digital technologies to be made available to students. However, there are strategies to be implemented by the authors of teaching materials. In order to guide educators to build accessible OER for people with learning disabilities, the following recommendations were generated, divided into general content, non-textual content (video, image, animation, audio) and exercises/activities. These recommendations can be inserted in an authoring tool for creating accessible digital material.

## 4.1 General Content

- Use student daily words. If you need to use unusual words, create a glossary with the meaning of these words.

- Do not use color, sound, shapes as the sole resource for understanding content and for feedback.
- Avoid using text in images unless they are essential (examples: trademarks and logos) or can be customized by the user.
- Do not insert animation of more than 5s if it is not essential.
- Create an index of content that will be displayed.
- Avoid using abbreviations.
- Maintain pattern of the objects that make up the material, such as titles, content, feedbacks and image description.
- The contents (textual, video, sound, etc.) cannot be too long.
- If possible, create materials at different levels of depth. Use the shallowest level to present the context and a deeper level, such as "read more".
- Use images, graphics and videos to help in understanding the content.

### 4.2 Non-textual Content (video, image, animation, audio)

- Enter information about the meaning of that content, its purpose (what it is for), and some accessible description of it.
- It is desirable that the video has subtitles in the same mother language as the readers.
- If the video has no subtitles, subtitle software can be used (such as Movavi Clips (https://www.movavi.com/), Wave.video (https://wave.video/), In-Shot (https://inshoteditor.br.uptodown.com/android), Clipomatic (https://www.apalon.com/clipomatic.html)
- Images should not have many visual elements, not to confuse
- Do not use too long sound-based information with too much different information.

### 4.3 Exercises/ Activities

- Establish different difficulty levels. Start with the least complex exercises / activities.
- Give feedback on the response to exercises / activities.
- If the exercise / assessment has a time limit, the teacher may set extra time or disable the use of time.

## 5    Conclusion

This paper has made recommendations for creating accessible OER for people with learning disabilities. These recommendations were based on the W3C, Universal Design for Learning guidelines, the openness principles and also on the authors' empiric experience in preparing accessible educational resources. Rely on the assumption that authors of educational resources will always make them in an accessible, and open way is a big mistake. Teachers often are not aware about accessibility nor openness, and they usually are not trained properly in using tools to create accessible, open resources,

nor even simple Web pages, for example. In this sense, this set of good practices when designing accessible OER could be helpful as a reference for this process. Further work points to the generation of recommendations for all types of disabilities, such as dyslexia, motor disability, deafness or low hearing, among others, as well as to the design of a computational artifact to help the accessible OER design process.

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