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# Open and Inclusive Technologies in the Complexity of Future Education: Designing a Research-Based Model

Tecnologías abiertas e inclusivas en la complejidad del futuro de la educación:  
diseño de modelo basado en investigación

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## ABSTRACT

Changing environments pose challenges for education, particularly for the inclusive education of people with hearing and visual impairments. How can open education and digital and flexible technologies provide pathways for inclusion in the context of complexity? This study aimed to analyze possibilities for open education and technologies by identifying current practices, challenges, and opportunities to propose an inclusive, open model in the framework of complexity in future education. The research-based design method involved applying questionnaires to 390 participants in an open and inclusive education program. The data analysis examined (a) current practices such as e-books, training courses, and sign language; (b) the challenges of quality open educational resources (OER), policies to support inclusion and diversity, and OER sustainability models to develop accessible and open digital materials; and (c) the components of an open educational model for inclusion that considers strategic elements for future education and emerging and innovative technologies. The study intends to be of value to teachers, trainers, developers, and decision-makers interested in new possibilities for open and inclusive education.

## RESUMEN

Los entornos cambiantes plantean retos para la formación y, de manera muy especial, para la inclusión educativa de personas con dificultades auditivas y visuales. ¿De qué forma la educación abierta y las tecnologías digitales y flexibles pueden aportar vías para inclusión en el marco de la complejidad? El objetivo del estudio fue analizar posibilidades de educación abierta y tecnologías, por medio de identificar prácticas actuales, retos y posibilidades, con miras a proponer un modelo inclusivo y abierto en el marco de la complejidad para el futuro de la educación. El método fue diseño basado en investigación, donde se aplicaron cuestionarios a 390 participantes en el contexto de un programa de educación abierta e inclusiva. El análisis de datos dan cuenta de (a) prácticas actuales como libros electrónicos, cursos formativos y lenguaje de señas; (b) identificación de los retos de recursos educativos abiertos (REA) de calidad, políticas de apoyo a la inclusión y diversidad, y modelos de sostenibilidad de los REA, para desarrollar materiales digitales accesibles y abiertos, y (c) los componentes de un modelo educativo abierto para la inclusión que contempla elementos estratégicos para el futuro de la educación y tecnologías emergentes e innovadoras. El estudio pretende ser de valor para profesores, formadores, desarrolladores, tomadores de decisiones, interesados en nuevas posibilidades para la educación abierta e inclusiva.

## KEYWORDS

Complex thinking, educational innovation, higher education, open education, inclusion.  
Pensamiento complejo, innovación educativa, educación superior, educación abierta, inclusión

## 1. Introduction

### 1.1 Inclusion and Complexity of the Future of Education

The socio-technical transformations shaping the third decade of this millennium challenge us like never before regarding the speed necessary for the adaptation and adequacy of our training, work, and development. These transformations also involve the digitalization of organizations and, in the educational environment, the evolution of components and systems, all with profound implications for learning communities (Ramírez-Montoya et al., 2022). The growth desired from these transformations, linked substantially to sustainable development, comes from universities and the higher education ecosystem through the skills and competencies developed in students that allow them to respond adequately to the needs of society as a whole (Suárez-Brito et al., 2022). Given the demands of the contemporary world, it is essential to train transversal competencies that allow new professionals (Cruz-Sandoval et al., 2023) to resolve complex problems through feasible and viable solutions in diverse contexts. From this perspective, the competency of complex thinking emerges as indispensable.

Aligned with the priorities of sustainable development, the training of professionals to face these challenges must be inclusive and accessible, serving vulnerable populations with the commitment to close the digital divide. Accordingly, some authors, such as Beltrán et al. (2019), recommend the development of teacher updating and training programs that promote the implementation of technologies to improve the digital skills of all members of the educational community. Similarly, some recommendations from UNESCO (2021) point to the unwavering commitment of organizations and governments to developing strategic initiatives and plans that open up new possibilities to connect and support educators and coalitions that share that commitment. In this way, future education, especially after the COVID-19 pandemic, shapes up with three main characteristics: (1) a growing demand for global problem solvers, (2) changes in the skills needed for the job, and (3) a shift towards a lifelong learning mindset (Kuykendall, 2022). Therefore, to attend to inclusive education in the context of complexity, the use of technologies and digitalization is essential for scaling skills.

### 1.2 Open Education with Inclusive Technologies

Technology significantly impacts open education; however, technological applications have not kept up with the pace of new developments related to caring for people with disabilities. Consequently, a plan to provide recommendations for these technologies is urgent. Global and regional bodies are already making efforts to issue recommendations for inclusion and to make these resources freely available to all (*Global Education Monitoring Report, 2020: Inclusion and education: all means all - UNESCO Digital Library, 2020*). In education, a wide range of available technologies not yet explored could update inclusive frameworks (e.g., technologies with applications such as the Internet of Things, commonly known as IoT) (Moraiti et al., 2022). In general, advances that incorporate artificial intelligence are also available today, such as textbooks, journal articles in EPUB format, assistive technologies for listening to text aloud, voice search engines, virtual reality,



metaverse environments, smart glasses, indoor navigation, smartphones with braille patterns, and robots (Fichten et al., 2022). Some web-based tools provide content for students with hearing impairments, for example, helping with signing and synchronized text-based instructions (Joy et al., 2022). Generally, an effective inclusive education with unique guidelines and personalized inclusion activities, supported by all these technologies, will advance universal equality in education.

The spectrum of special conditions for learning is broad. In this sense, inclusion activities must be comprehensive and include as many special abilities as possible. Previous technological approaches will not be possible if the quality of life of people who need special support or resources appropriate to their disability circumstances is not considered, i.e., treatments more personalized to their disability needs should be considered (Ramírez-Montoya et al., 2021). Once a more standardized design has defined the characteristics of these technologies, their optimization will be another challenge. The literature says that new AI tools will innovate assistive technology algorithms to reduce the risk associated with their use and improve the lives of people with special conditions (Trewin et al., 2019). Finally, it is imperative to include in the pool of personalized resources for this open education the requirement for specialized teacher training and the improvement in the infrastructure designated for this great purpose (Ramírez Montoya et al., 2022). All these aspects will contribute to the equality, protection, and justice for people with special needs.

### 1.3 Objectives and Questions

The study's objective was to analyze the potential of open education and technologies by identifying current practices, challenges, and possibilities to propose an inclusive and open model within the framework of complexity in future education.

#### **Specific objectives:**

1. Recognize current practices in open education that address both visual and auditory learning needs.
2. Analyze the challenges related to creating digital materials that are accessible and open to individuals who are deaf or hard of hearing.
3. Suggest the elements of an inclusive and open educational model that contributes to facing the complexity of future education.

To this end, we propose the following questions:

1. What are the current open education practices in institutions to meet the needs of visual and auditory learning related to open resources and technologies?

2. What challenges are faced when developing accessible and open digital materials for deaf and hard-of-hearing people?
3. What components must an inclusive, open educational model have to be able to address complexity in future education?

## 2. Methodology

The method was research-based design (RBD). RBD requires information analysis, ideation processes (Edelson, 2002), and previous experience integrating it into open education. Thammetar and Khlaisang (2019) presented RBD designing a strategic plan for open education through technologies in higher education institutions. With this direction, the RBD provides a basis for devising new solutions.

Within the framework of an open and inclusive education training program, which was the object of study in this research, we integrated data collection techniques, made measurements, and analyzed data, looking for lights to delineate the components of a model. The study's objective was to analyze the potential of open education and technologies by identifying current practices, challenges, and possibilities to propose an inclusive and open model within the framework of complexity in future education. In particular, questionnaires were applied to 390 participants in the context of the open and inclusive education program, distributed in two webinars. 207 people participated in the first webinar, and 183 in the second.

The study was developed in three key moments of research-based design (RBD):

- **Categories and Data Collection:**
  - Current Practices: Exploration of open education practices to meet visual and auditory learning needs.
  - Challenges: Identification of the main challenges in the development of accessible digital materials for deaf and hard of hearing people.
  - Possibilities: Evaluation of the processes necessary to produce accessible digital texts. Questionnaires with open and closed questions were used to collect information, covering three main categories with six questions in total.
- **Measurement and Data Analysis:**
  - Measurements were graphed using spreadsheets and Python libraries.
  - The descriptive analysis was contrasted with the empirical evidence from the surveys and the theoretical information from the webinars.

- **Open and Inclusive Model Design:**

Based on the data collected, an open and inclusive educational model was designed that integrates philosophical, theoretical, political and educational process components.

- **The variables used in the study were the following:**

- **Independent variables:**

1. Type of open educational practice implemented.
2. Type of open educational resource (OER) used.

- **Dependent Variables:**

1. Accessibility and usability of digital materials for people with hearing disabilities.
2. Effectiveness of the proposed educational model in terms of inclusion and complexity.

- **Covariates:**

1. Institutional context.
2. Demographic profile of the participants (age, gender, educational level)
3. Type of disability
4. Previous Experience with Open Educational Resources

### 2.1. Open and Inclusive Education Program (OpenEd)

The study was developed within the framework of OpenEd, which aimed to contribute to education and reduce inequalities by using and disseminating open educational resources (OER) among strategic actors of academia and society. OpenEd comprised open and inclusive education experts from Australia, Canada, Spain, Mexico, and South Africa (Figure 1).

**Figure 1**

Portal of the *Open Ed* program



Note: <https://www.wununesco.world>

The OpenEd program consisted of a series of webinars delivered in English and Spanish, with questionnaires applied to participants. The study presented here had two webinars that specified the following objectives:

- Webinar 1: Creating eBooks – Current Considerations for Students Who Are Deaf and Hard of Hearing (Weber, 2021a). This webinar explored universal design principles and accessibility frameworks developed by UNESCO and current systems for providing e-books to deaf and hard-of-hearing students. The seminar discussed ways to go beyond the standard accessibility provision to promote multilingual language acquisition in children and young people with hearing impairments.
- Webinar 2: OER Publishing Resources for Deaf Students (Weber, 2021b). The webinar reviewed research-based design principles regarding e-books for deaf children, considerations for further development, and a planning pathway for creating e-books using available OER platforms. Attendees received samples of an e-book interface available through PressBook with content for multilingual deaf people.

## 2.2 Participants

The program targeted educators, teachers of the deaf and hard of hearing, special education teachers, university academicians (in deaf studies, disability studies, deaf education, linguists), non-profit organizations or NGOs, community-based organizations, deaf organizations (local, regional, national, international), government representatives from the education and health sectors, and technology companies. There were 207 participants

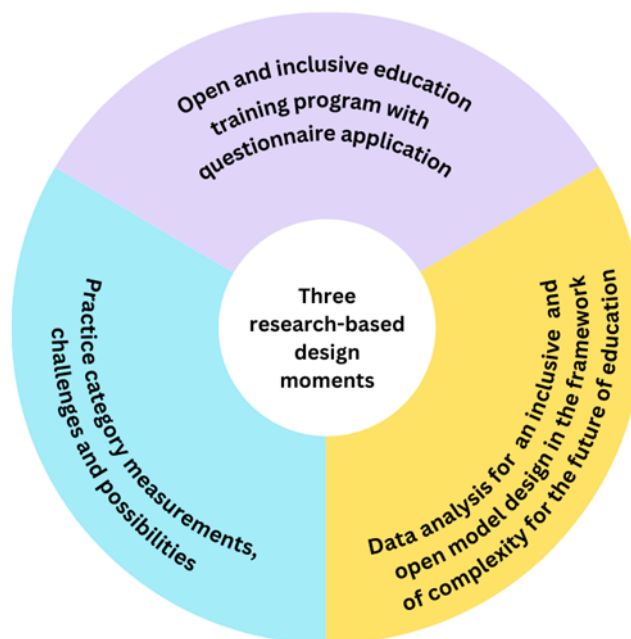
in the first webinar and 183 in the second who comprised the intentional sample in this study and intervened in the responses of the training program.

### 2.3 Procedure and instrument

The study procedure occurred at three points in the research (see Figure 2).

**Figure 2**

*Three instances of Research-based Design.*



Note: *Own elaboration*

Categories and data collection in education: In OpenEd, the study used questionnaires with open and closed questions. The instrument consisted of three categories, with six questions:

- **Current Practices**

- What open education practices are in place in your organization, school, or institution to meet the learning needs of the visually impaired and hard-of-hearing students regarding accessible e-books and digital texts?
- What are the current practices of design principles for e-books for deaf learners in your organization, school, or institution?

- **Challenges**

- What are the biggest challenges to developing e-books or accessible digital texts for deaf and hard-of-hearing people?
- Indicate, in order of importance, your institution's training needs related to developing a visual-centric e-book.

▪ **Possibilities**

- Please indicate, in order of importance, the processes required to produce accessible digital texts (e-books) for deaf and hard-of-hearing students (1 is most important and 4 is least important).
- The webinar presented Pressbooks, an e-book creation platform that helps create Open Educational Resources (OER) through support for H5P content generation. In your estimation, what is the potential of your institution or organization to create interactive H5P content that can be created, shared, and reused by deaf learners?

▪ **Data measurement and analysis.**

Measurements were made by contrasting the category data of current practices, challenges, and possibilities using an Excel spreadsheet and graphing the data using Python libraries. The descriptive data analysis contrasted empirical evidence from the surveys with the theoretical information derived from the conceptual framework of the two Webinars offered in the Open and Inclusive Education Framework. In the first webinar, the following question appeared: What do you consider the biggest challenge facing the development of e-books or digital texts accessible to deaf and hard-of-hearing people? The frequencies (%) of 7 types of challenges were identified (207 people responded). The second webinar posed the following question: What are the current practices regarding the design principles of e-books for deaf learners in your organization, school, or institution? The 183 open-ended responses were categorized, identifying 16 types of practices.

▪ **Open and inclusive model design.**

The research shed light on designing an inclusive and open model within the framework of complexity in future education. The design incorporated four essential components: philosophical, theoretical, political, and educational process (Escudero-Nahón & Ramírez-Montoya, 2021; Ramírez-Montoya, 2010). Each component allows for integrating future education priorities in terms of the educational needs detected in the study, with the guarantee of access to and



inclusion of educational resources, programs, and environments and the relevant policies and practices that facilitate it.

## 2.4 Ethical factors

The study took care of the ethical processes involved in the study, including participants' informed consent and the treatment and protection of data, analyses, and publication of data. Both epistemological aspects and ethical care are necessary to take care of the information (Smith, 1990), and, in this sense, the content work was analyzed with adherence to the information collected and contrasted in the theoretical discussions on the subject studied.

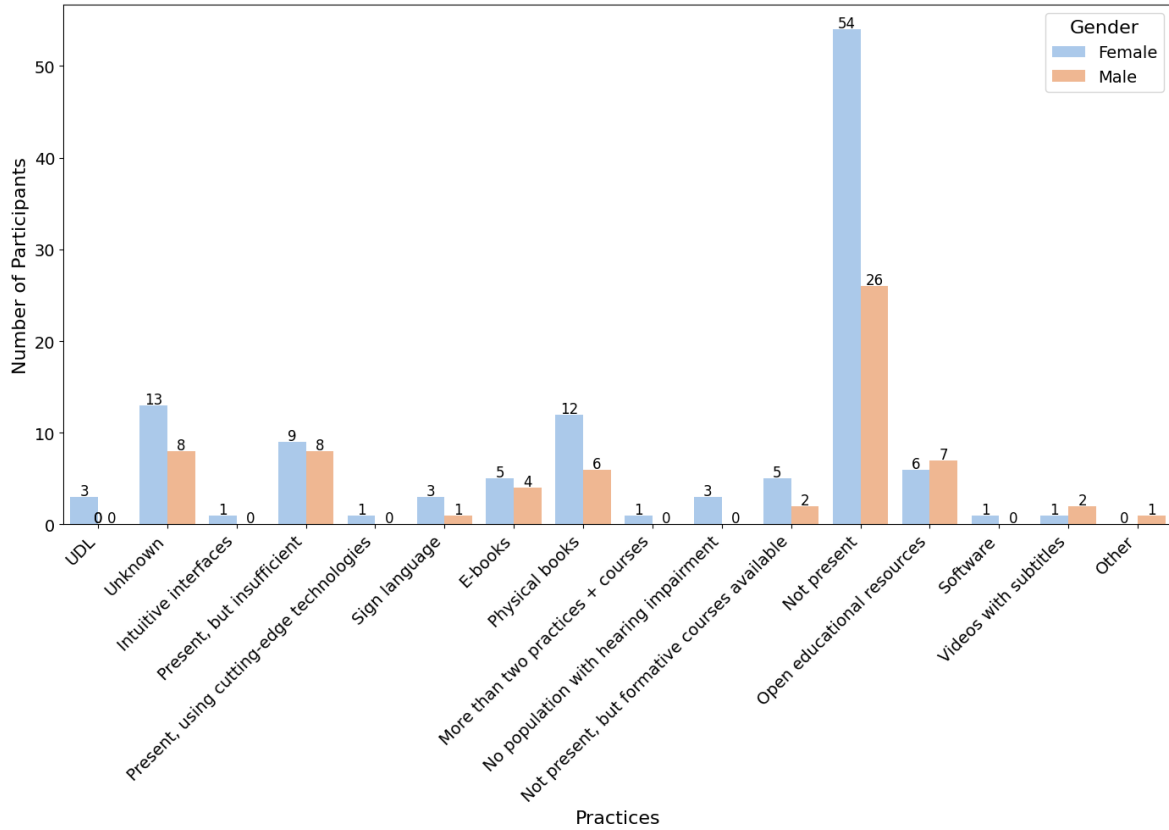
## 3. Analysis and Results

### **What are the current open education practices being carried out in institutions to meet the needs of auditory learning (with and without visual design frameworks) related to open resources and technologies?**

When we analyzed educational practices to meet auditory learning needs related to open resources and technologies, we identified the following types of practices (the number of individuals applying them is indicated after each practice): Universal Design for Learning (UDL) (3); auditory interfaces (1); patient practices in the health sector (1); practices supported by cutting-edge technologies (4); sign language (9); e-books (18); physical books (1); the implementation of two practices plus courses (3); training courses (13); the implementation of these resources in combination with open training (1); software (3); and auditory resources (1). Unfortunately, 80 participants surveyed indicated that there were still no practices in their institutions, 21 mentioned that they were unaware of them, and 17 said that there were some, but they were insufficient. Seven said they did not have a population with hearing disabilities in their institution (see Figure 3).

**Figure 3**

*Educational practices for auditory learning. UDL: Universal Design for Learning*

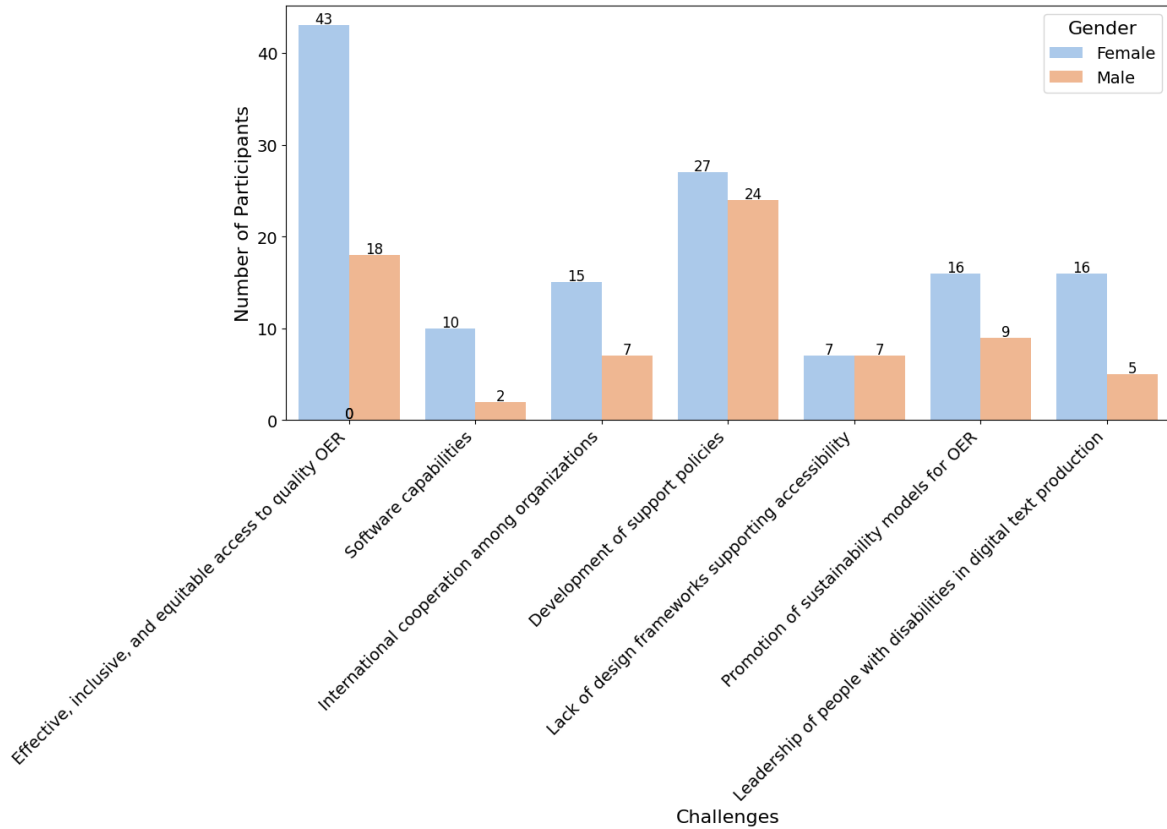


### **What challenges do you face in developing accessible, open digital materials for deaf and hard-of-hearing people?**

The main challenges related to the development of digital materials for people with hearing impairments are as follows (the number of individuals is indicated after each challenge): affective, inclusive, and equitable access to OER of sufficient quality (61), lack of support policies (51), sustainability models for OER are not promoted (25), insufficient international cooperation between organizations (22), lack of leadership of people with disabilities in the production of digital texts (21), lack of a virtual design framework that supports accessibility to resources (14), and insufficient capacity of software to address teaching individuals with these problems (12). (See Figure 4.)

**Figure 4**

*Challenges in the development of accessible e-books or digital texts for people who are deaf or hard of hearing*

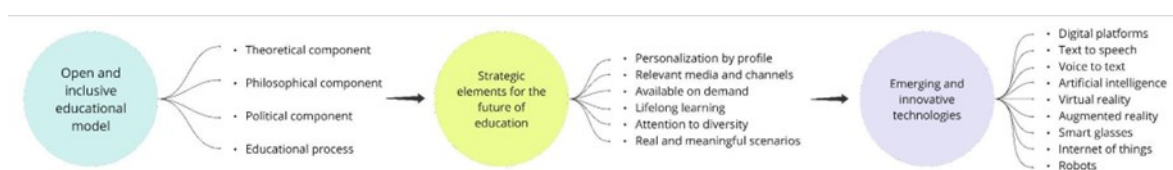


### What components can an inclusive, open educational model have that address complexity in future education?

To define the characteristics of an inclusive, open educational model that addresses the complexity of the future of education, one must identify the components that sustain it, the elements derived from each component, and the enablers that transfer its benefits. From the information collected, we defined that the four components of an open and inclusive educational model, the theoretical, philosophical, political, and educational process, favor implementing the strategic elements for the future of education. In this way, policies, programs, practices, and open resources can be designed to be meaningful and, under principles of inclusion, consider diversity and the students' context, abilities, or characteristics (Figure 5).

**Figure 5**

*Components of an open and inclusive educational model for the future of education*



Note: *Own elaboration*

Finally, as presented in Figure 5, the enablers of training experiences promote learning in a diverse environment by applying emerging technologies and technological resources. By providing access to all students regardless of age, condition, ability, or characteristics, we invite them to generate physical or digital environments that stimulate the development of complex thinking skills, foster creativity, and increase the willingness to continue learning. Also, connectivity and digital platforms promote collaboration and cooperative learning among students, educators, and decision-makers towards open and inclusive policies. The model proposed in this study establishes a frame of reference for those committed to generating these types of technological resources and enablers in the search for quality open education for all.

#### 4. Discussion

##### **a) Current practices like intuitive interfaces, sign language, e-books, software, and other cutting-edge technologies.**

The particular standardized educational contexts for the inclusion of all people in education imply the transformations that must arise in institutions based on the free, equitable, and complex thinking of mentors and specialists sensitive to this situation, which will comprise a new stage toward the sustainability of education. Such transformations are gradually being adopted in institutions, as each disability requires a complex and substantial approach. As can be seen in Figure 3, the approach to educational practices in Ibero-American countries specifically related to the design of e-books for students with hearing disabilities is linked to educational practices that are just being implemented, that are insufficient, that are in the awareness phase, or that do not yet include cutting-edge technological elements.

Technological resources based on sign languages are the most predominant. Weber and Skyer (2022), in their research related to the identification of practices, mention that arduous work is mainly identified in the creation of frameworks for design, the implementation of technological resources, a multimodal pedagogy, and, similar to what we have identified, the implementation of resources for sign language. Individual initiatives and the implementation of complex thinking follow this. The approaches are multiple, and when analyzed comprehensively, it is possible to identify psychological, social welfare, public administration, artistic, ergonomic, architectural, computational, and ethical frameworks, somewhat coinciding with the five models for the approach to disabilities suggested by Alsalem and Alzahrani: 1) Human Development, 2) Public Studies, 3) Cultural, 4) Technological, and 5) Ethical (Alsalem & Alzahrani, 2023). All these practical approaches help identify the challenges to be solved to attain equality and efficiency of thinking and learning, without forgetting that for a successful approach, complex thinking is paramount as it ensures that students obtain the same levels of learning.

##### **b) Identification of challenges such as equitable, inclusive access to quality OER, software capacities, international cooperation, development of supportive policies,**

### **lack of design frameworks, and promotion of sustainability models for OER for the development of accessible and open digital materials:**

Identifying current practices related to the design of digital texts for deaf students deepens the thinking of specialists and trainers to design context-dependent frameworks, appropriate infrastructure, and standardized methods for their efficient implementation. However, there are still some challenges in this technological age. Figure 4 shows the main challenges identified per the design of digital content based on the opinion of experts from Ibero-American countries: the lack of access to quality, inclusive, and equitable OER; the lack of supportive policies and sustainability models for them; insufficient international cooperation among organizations; lack of leadership of persons with disabilities in the production of texts; lack of virtual universal design frameworks; and insufficient software capacity. Our results closely align with the achievement of Sustainable Development Goal Number 4 for inclusive and equitable quality education and complement the challenges identified by Matjilla in its e-learning program (2023): lack of entertainment and novelty for students, insufficient access to online communities and web content, lack of self-learning approaches, the promotion of critical thinking, and the lack of administrative responsibilities (Matjila, 2023). Pedagogical, managerial, social, and technical challenges have also been identified, but, above all, the lack of resilient open education in the context of affective dimensions and the inclusion of pedagogies aimed at caring for people with these abilities (Manual of Open, Distance, and Digital Education | Junhong Xiao - Academia.edu, 2023).

In summary, and responding to the general opinion, Kocdar and Bozkurt indicated that quality in the design of educational materials can be ensured through accessibility and the recognition of the principles of Universal Design for Learning through the use of assistive technologies and adaptations (Kocdar & Bozkurt, 2023). The nature of the challenges will depend on the countries' cultures, pedagogies, and levels of inclusiveness, and overcoming them will be possible with the participation of learners and experts and governmental commitment to sustainable agendas.

### **c) Articulation of the components of the open educational model:**

The components of an open educational model for inclusion work to transform education under an open and inclusive perspective that integrates open resources and technological enablers to promote open access and collaboration. As shown in Figure 5, the articulation of the four components that support the model and the application of emerging technologies link to the generation of the elements that allow the fulfillment of international commitments to develop public policies for inclusion and access to quality education for all. The conditions are in place because the work environment and global challenges demand greater and better capacities in human resources, which has led to a disposition for continuous learning throughout life (Kuykendall, 2022). Therefore, the value of a model aligned with the open and inclusive approach lies in favoring the creation of new ways to approach the training of professionals with relevant skills to transform socio-technical systems within the framework of complexity and sustainable development.

## 5. Conclusions

The current state of education is a process of transformation towards inclusion and accessibility in frontier education, especially for people with hearing disabilities. As institutions incorporate emerging technologies and applications, new practices and initiatives emerge in the various institutions of Ibero-America. However, a low proportion of the population participating in the Webinars knew about good practices and guidelines for designing inclusive education materials. For example, only 1.5% identified the application of Universal Design for Learning. Also, only 2% mentioned implementing cutting-edge technologies in such learning, and 44% indicated that there were still no programs in their institutions. In the second webinar, participants identified the challenges, such as the lack of quality resources, insufficient support policies, and the need for international cooperation, one of the most significant deficiencies in the governmental, industrial, and academic sectors.

The study started with the question: How can open education and digital and flexible technologies provide pathways for inclusion in the context of complexity? The analysis identified the following: (a) current practices such as e-books, training courses, and sign language; (b) identification of the challenges of quality open educational resources (OER), policies to support inclusion and diversity, and OER sustainability models to develop accessible and open digital materials, and (c) the components of an open educational model for inclusion that contemplates strategic elements for the future of education and emerging and innovative technologies. In summary, for open education and digital and flexible technologies to bring inclusion into the context of complexity, it is essential to adopt a complex thinking approach, ensuring accessibility to the full range of resources and a framework for universal design, not just for learning, but for the design of educational materials for these differently-abled individuals.

The implications for practice and future research include identifying challenges in designing accessible and open digital materials, which is fundamental to moving towards a fully inclusive and quality education. These challenges must be addressed soon; they range from the lack of entertainment and novelty for students to the need to promote critical thinking and the inclusion of pedagogies geared toward caring for people with disabilities. In addition, we emphasize the importance of the participation of students with these disabilities, experts, and the commitment of governments to implement sustainable agendas.

The study has limitations due to the target population (Spanish-speaking and Anglo-Saxon samples), leaving opportunities for future analyses that cover different linguistic populations with differentiated strategies. This study opens up various possibilities for designing new study ecosystems that help obtain focused results for personalized treatments according to each type of disability. The approach towards an open educational model for inclusion and education transformation signifies a future opportunity to integrate open resources and emerging technologies that promote open access and collaboration. This approach is especially relevant in a world where lifelong learning is essential for people's lives to be sustainable and fair. An open and inclusive educational model can contribute significantly to training professionals with relevant competencies to address complex challenges and promote the sustainable development required by today's society.



## Authors' Contribution

Conceptualization, M.S.R.-M. y W.J.C; Data curation, F.C.-M. y I.A.-I; Formal Analysis, M.S.R.-M., F.C.-M. y I.A.-I; Funding acquisition, M.S.R.-M.; Investigation, M.S.R.-M., W.J.C, F.C.-M. y I.A.-I; Methodology, M.S.R.-M., F.C.-M. y I.A.-I; Project administration, M.S.R.-M.; Resources, M.S.R.-M. y W.J.C; Supervision, M.S.R.-M.; Validation, F.C.-M. y I.A.-I; Visualization, F.C.-M. y I.A.-I; Writing – original draft, M.S.R.-M., F.C.-M. y I.A.-I; Writing – review & editing, M.S.R.-M., F.C.-M. y I.A.-I.

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