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IMPACT OF ICT ON UNIVERSITY STUDENTS WITH VISUAL IMPAIRMENT

# Impact of ICT on university students with visual impairment

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**Information and communication technology (ICT) are creating new horizons in the educational responses to students who have a disability in higher education. This study aims to provide the academic community with an overview of the research pertaining to ICT as a support for students with low vision or blindness. Data were obtained through a systematic literature review, covering the period from 2010 to 2021, in four relevant scientific and academic databases. The sample consists of 17 studies. A descriptive and quantitative methodology was used. The most significant bibliometric data are presented, and through bibliometric maps, a method based on co-word analysis, clustering techniques and visualization techniques were applied to determine the fields of study and research. The results indicate that research on ICT and visual impairment in higher education remains scarce and focuses on the educational needs of students with visual impairment in accessing and transitioning to higher education.**

***Key words:*** **higher education, visual impairment, students with disabilities, inclusion, ICT**

## Introduction

The removal of social, cultural and educational barriers is not only a matter of public interest but also a concern that has been expressed (sometimes by legal imperative) in the obligation to adapt infrastructures and services so that they are accessible to the whole of society, thus achieving one of the


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most important constitutional rights, equal opportunities. Accordingly, the European Union is committed to harnessing the potential of information and communication technology (ICT) to ensure that no one is excluded, especially people with disabilities.

In the case of visual impairment, this limitation has personal, social and educational repercussions that directly impact the individual's quality of life and their relationships with others. Indeed, relationships are not always possible or, rather, have different levels of action depending on the individuals' different characteristics. As established in the *International Classification of Functioning, Disability and Health (ICF) 2001*, specifically in relation to visual disorders, visual impairment is defined as the loss or abnormality in the structure or function of the visual system caused by disease, trauma, genetic alteration or degenerative process. Visual impairment is the restriction or absence of the ability to carry out the activities of daily life due to poor vision. Visual impairment can be classified into two groups: people with low vision and those who are blind.

People who are visually impaired may find themselves at a social disadvantage due to their visual limitations, which prevent them from carrying out their expected contextual roles (according to their age, sex, social and cultural factors). The limitation of activity and restriction of participation can extend to all areas of life for those with visual impairments, including learning, communication, mobility and interpersonal relationships. However, there are potential ways to overcome some of the problems resulting from visual limitations. One such way is using ICT as a pedagogical tool to support visually impaired students.

The work presented here aimed to evaluate, using both bibliometric and thematic variables, the research outcomes of educational attention paid to visually impaired students in higher education settings utilizing technology support. We looked at studies indexed in the selected electronic databases to detect limitations and identify new challenges.

The researchers considered the following basic questions: what do we know, what do we need to know and what can we do when educating visually impaired students with ICT support. In essence, these questions mirror the research process: the literature review assesses what we know, the research findings examine what we need to know and the implications section asks what can we do.

This study is necessary for several reasons. First, it increases the field of knowledge about ICT and visual impairment. Second, the information obtained contributes to a better understanding of the knowledge structure of the scientific domain of ICT and visual impairment by analyzing research articles published in high-impact journals. By identifying the lines of research and their interconnections, based on the information contained in the databases, our understanding of this topic will improve. Finally, knowledge of the scientific production analyzed will provide insight into the development and evolution of ICT in the field of visual impairment, making an effective contribution to reducing the possible digital divide due to disability.

## ICT and visual impairment in higher education

*What we know*

In recent years, universities have faced the challenge of moving towards inclusion through developing new proposals that respond to the variability of students' profiles and learning situations. The policies and strategies adopted are resulting in more and more students with disabilities accessing university (Villouta & Villarreal, 2022). However, in addition to access, it is necessary to facilitate retention and promote the success of students with disabilities, their participation in the inclusive community, their graduation and their integration into the labour market.

This demand is highlighted in different international declarations, for example, the European Union's Europe 2020 Strategy (European Commission, 2010) and the United Nations Agenda 2030 (United Nations, 2015). International reports, such as that of UNESCO (2020), also decry the fact that people with disabilities are less than half as likely to be employed as people without disabilities. Sustainable Development Goal (SDG) 4 of the European 2030 agenda on education calls for ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all by 2030. This goal emphasizes the importance of inclusion and equity as the foundation for quality education and learning (Fernández-Batanero et al., 2021).

Yet, despite the progress that has been made, university students with disabilities identify barriers in their university careers, such as the lack of teacher training, insufficiently adapted curricula and teaching materials, and inaccessible infrastructures (Edwards et al., 2022). Access to quality higher education is essential for all students; however, those with disabilities require additional guarantees and tools to enable them to participate in university equally.

For students with visual impairment, ICT has become an important means through which they can learn and access learning materials. Learning with ICT as a support for people with visual impairment in the university environment has been the subject of research in recent years, becoming an important part of supporting this demographic's learning, starting from the first moment of their access and transition to university. The technologies used to support the functional limitations of people with disabilities are called assistive technologies (Emiliani et al., 2011). In this regard, students with visual impairments see this transition as a collective effort where digital tools play an enabling role (Pacheco et al., 2018).

Internationally, the use of assistive technology in this group of students has been studied, for example by Huber et al. (2016) and Remington and Pellicano (2019), identifying the most advantageous academic adaptations: extra time for exams, learning materials in different formats and greater autonomy. Nisbet (2020) and Kisanga and Kisanga (2020) focused their studies on the barriers that limit full participation in higher education, such as high reading demands, group work and the inability to participate in some activities (Lourens & Swartz 2020; Papadopoulos & Koutsoklenis, 2019; Reed & Curtis, 2019) as well as the impact on academic performance (Kelly & Smith, 2011; Richarson, 2015). Odame et al. (2019) detected the difficulties of students with disabilities in carrying out external placements, as companies are not prepared to respond to their needs. For example, they lack assistive technologies, such as text-to-speech software. This prevented the students from communicating through conventional means, which in turn prevented them from establishing collaborative relationships with colleagues.

Another area of study in recent years has been the use of ICT in distance higher education institutions in relation to the learning experiences of students with visual impairment (Koustriava, 2021; Mokiwa & Phasha, 2013). More recent studies have focused on learners with visual impairment and their situation during the COVID-19 health crisis (Gombas & Csakvari, 2021). In the latter study, visually impaired students demonstrated the negative effects of confinement on their participation and independence; accessibility problems were common, both in purchasing essential goods and accessing remote study and work.

The digital skills of teachers of students with visual impairment have also been studied (Zhou et al., 2019), highlighting the importance of having

aware, informed and technologically trained teachers who know how to provide tools and strategies to facilitate academic success.

However, the truth is that the volume of studies carried out on visual impairment in higher education is significantly lower than those carried out at non-university educational levels, hence the need to further study assistive technologies in university students with visual impairment in order to ensure greater inclusion in the academic and professional worlds. In this sense, it is essential to close the research gap by heeding the impact of ICT on students with visual impairment.

## Method

### *Aim and research questions*

This study aims to provide the academic community with an overview of the research pertaining to the use of ICT in the education of students with visual impairment in higher education settings. To achieve this, the following research questions (RQs) were developed:

- What is the general state of academic research on ICT for visually impaired university students?
- What are the findings regarding the impact of ICT on the education of students with visual impairment in higher education?
- What are the emerging themes in the research pertaining to the use of ICT for visually impaired learners in higher education?

### *Data sources and search strategy*

This section presents the method used to obtain the data for the study. In keeping with the study's purpose, it was conducted in accordance with the criteria and recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement (Moher et al., 2009). This guideline aims to improve the presentation of systematic reviews. In addition, network mapping analysis techniques (Knoke & Yang, 2008) were used, creating visual representations via VOSviewer software. The searches were conducted in January 2022, following the steps presented below.

A systematic search was conducted of four electronic databases: Web of Science (WoS), Scopus, ERIC and Google Scholar. These databases are considered internationally relevant and prestigious in the field of

education, which is why they were selected. The search descriptors, extracted from the ERIC thesaurus, were applied to the title, abstract and/or keyword fields. For rigor, the Boolean operators 'AND'/'OR' were applied. Thus, the search strategy was ('Student' OR 'Pupil') AND ('Higher Education' OR 'University') AND ('Training program' OR 'Teaching methods' OR 'Learning processes' OR 'school-based') AND ('Technology' OR 'ICT') AND ('Visual impairment' OR 'Blindness' OR 'Vision Loss' OR 'Visual Disabilities') AND ('Effectiveness' OR 'Impact' OR 'Barriers' OR 'Opportunities').

*Inclusion and exclusion criteria*

To narrow down and discriminate the research outputs to answer the research questions, eligibility criteria were determined based on the PICoS strategy: population, the phenomenon of interest, context and study design (see Table 1) (Pertegal-Vega et al., 2019).

The search was limited to the last few years (2010–2021) to extract the most current documents in terms of the research problem addressed. Other documents – such as theses, books, conference proceedings or reports – were excluded.

*Selection of studies*

This process was carried out in four phases: identification, screening, suitability and inclusion. The initial search, based on the use of descriptors, yielded a total of 143 results in the different databases. To reduce publication bias, we manually searched the studies' reference lists, identifying three additional studies. In the second phase, after an initial review, duplicate studies were eliminated. This process involved eliminating 45 records. The full texts of the remaining 119 papers were read and thoroughly reviewed to ensure that the selected articles met the established criteria. Consequently, 93 papers were excluded. Finally, the results of the database

**Table 1: Eligibility criteria**

| | **Eligibility criteria** |
|---|---|
| Population | Students with visual impairment |
| Phenomenon of interest | ICT as a support for visually impaired university students |
| Context | University/higher education |
| Study design | Articles published in peer-reviewed scientific journals in recent years (2010–2021) |

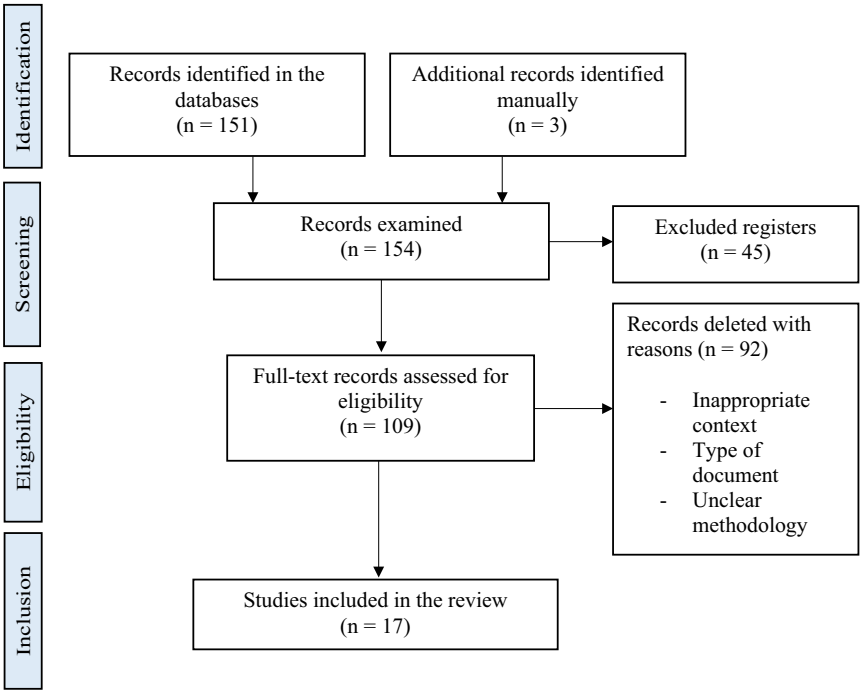
searches yielded a total of 17 potentially valid articles for the present review. The selection procedure is represented by the PRISMA flow chart in Figure 1.

*Data extraction and analysis*

Each stage of the literature search and selection process, and assessment of eligibility was conducted by the authors, and any conflicts were resolved by discussion and consensus, which was reached for all of the included studies.

Subsequently, the identifying particulars of the 17 selected articles were synthesized in an Excel database, detailing all relevant information (author's name, year of publication, method, geographical coverage, purpose of the research, opportunities and challenges of ICT for learners with visual impairment) to generate a documentary corpus to facilitate the review. The studies included in the review are marked with an asterisk (*) in the reference list.

**Figure 1: Flowchart of the PRISMA systematic review process**



The data were synthesized quantitatively and qualitatively for the analysis procedure based on the three research questions.

## Results

*What we need to know*

This section presents the results of the literature review. First, an overview of the selected articles is presented. Second, the impact of the use of ICT in higher education on students with visual impairment is analyzed in terms of the benefits and challenges experienced by these students. Third, the network maps are presented to delimit the emerging lines of research in this field.

The coding of the articles selected for review allowed the following contributions to be identified:

The analysis of the articles reviewed (17), published in peer-reviewed journals, shows the evolution of research in this field. Thus, if we look at the year of publication, we can see that the studies were mainly carried out between 2017–2021. Between the years 2010–2016, a reduced number of articles was published.

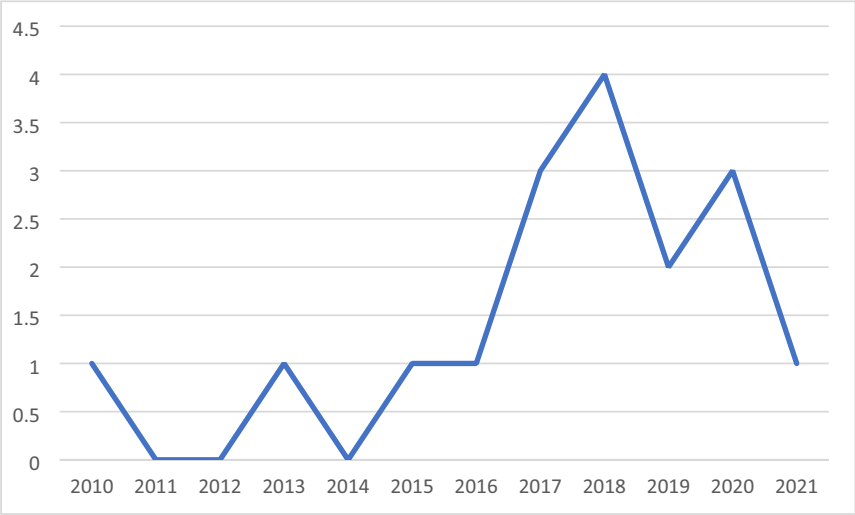
Thus, we can summarize that publications before 2017 were scarce or nonexistent; however, since then, research on this topic has increased (although not significantly). This may indicate that research on the application of ICT with visually impaired students in higher education is still at an early stage, but as technology has become more prevalent in inclusive education, the number of relevant published studies has increased (Figure 2).

Regarding geographical location, the articles published detail studied conducted in different countries. The majority were carried out in North America, with Mexico standing out (n = 2), followed by Europe, with Spain standing out (n = 2). Few studies were conducted in Africa or Asia. This suggests that the use of ICT for students with visual impairment in the university context generates interest among researchers worldwide.

In terms of study design, most of the published articles analyzed data using qualitative methods (62.5%) rather than quantitative studies (25%). A small proportion of the papers used mixed methods (12.5%).

Then, to answer the second research question related to the impact of ICT use in higher education with this group of students, two categories were posited:

**Figure 2: Articles by year of publication**




opportunities and challenges. This was followed by a detailed quantitative analysis process.

The main results addressed in the reviewed studies refer to the opportunities/benefits that technologies offer students with visual impairment. Among the main benefits identified are increased access to educational materials (32%), meeting educational needs (21%), adapted to everyone and promoting student learning (19%). To a lesser extent, they promote participatory and collaborative learning (16%) and enhance future employment prospects (12%).

However, despite the opportunities technology offers students with visual impairment, the reviewed studies also highlight that this demographic still faces different challenges in higher education. Thus, in the category of challenges, among the many issues that need to be addressed were identified as low availability of resources (37%), lack of (both teacher and student) training (25%) and accessibility (technological and pedagogical) (19%). To a lesser extent, affordability (13%) and the effectiveness of tools (6%) limit the use of technologies.

To identify emerging themes and trends in the research in this field, keyword analysis of the studies was conducted using VOSviewer software. This tool

allows the processing and analysis of co-occurrence data using graph visualizations. In short, it allows the distribution of the most frequent descriptors to be observed. In this case, after applying the minimum occurrence index of five, 41 items were found. Thus, of the total number of keywords analyzed, the 10 with the most occurrences are shown in Table 2. The most frequent keywords in the research are also those with the highest link strength index. This value indicates the importance of a descriptor in the field of study by being associated more often with another descriptor.

Figure 3 shows the network of co-occurrence of keywords that allows the identification of the distribution and relationship of the main themes discussed in the research. These are represented by circles; the higher the frequency, the larger their size. In addition, they are grouped by and connected by clusters. Each cluster (differentiated by color) reflects the topic that has been addressed in scientific research in the field of study. In this case, three clusters are differentiated that define the main research topics in this field.

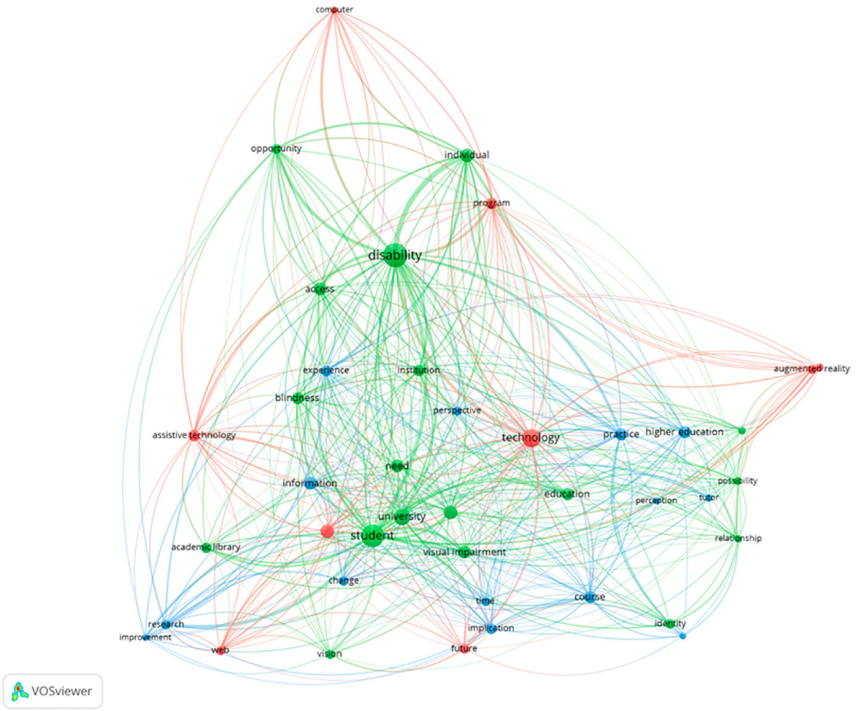
The first cluster (green) has the highest number of keywords (28) and occupies a central position, indicating that it is a topic of major interest in the analyzed material. This cluster is related to opportunities for access to university for students with visual impairments. Among the keywords that stand out in this cluster are *disability*, *student*, *university*, *visual impairment* and *need*.

The second cluster (blue), which has 14 keywords, also occupies a central part and is therefore also the subject of much attention in the research. This cluster relates to the experience and perceptions of students with visual impairment

**Table 2: Keywords with the highest number of records and strength**

| Keywords | Records | Strength |
|---|---|---|
| *Disability* | 38 | 436 |
| *Technology* | 38 | 401 |
| *Student* | 36 | 332 |
| *Visual impairment* | 32 | 223 |
| *Course* | 32 | 198 |
| *Assistive technology* | 30 | 191 |
| *Accessibility* | 30 | 168 |
| *Practice* | 30 | 160 |
| *Higher education* | 27 | 132 |
| *Information* | 23 | 127 |

**Figure 3: Co-occurrence network of keywords**

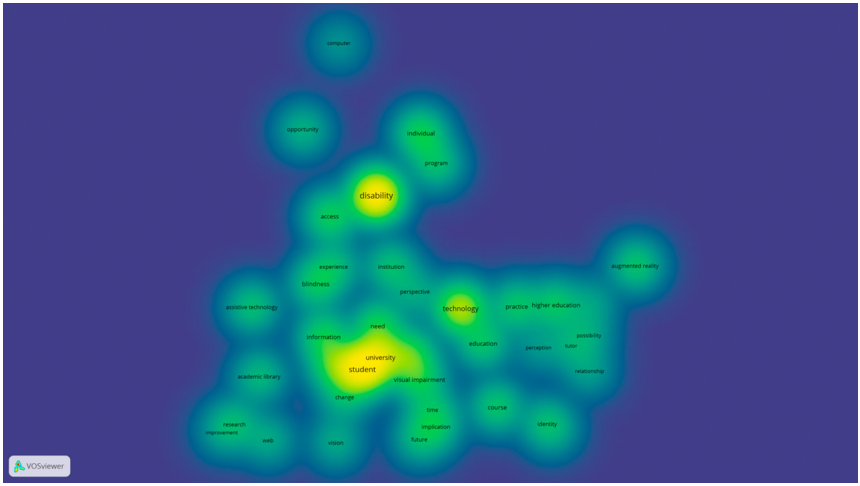



in accessing higher education. Among the main keywords are *information*, *experience*, *practice*, *higher education* and *implication*.

Finally, the third cluster (red) comprises nine words. This cluster has received less attention in the research and relates to the type of ICT tools used by students with visual impairment. It is composed of *technology*, *assistive technology*, *web and augmented reality*.

To complete the process of identifying the main themes, the bibliometric density map was analyzed, showing the relevance of the keywords under evaluation (Figure 4). The keywords are placed on the map, and the density and color reflect their interest and development in the field of study. Keywords in yellow are characterized by their importance and maturity in the field of study, while those in green are emerging keywords.

**Figure 4: Keyword density map**




## Discussions

This review allowed us to synthesize the results of the research material related to ICT as a support for students with visual impairment in higher education between 2010 and 2021, as well as to analyze the impact of the use of these tools in education on this group of students in the university context. Thus, considering the articles analyzed, the discussion section is organized around the three research questions that guided this systematic review.

*What is the general state of academic research on ICT for visually impaired university students?*

In response to the first research question (PI1), about the general state of research on ICT for university students with visual impairment, we can establish that research on ICT and visual impairment in higher education in recent years has been underdeveloped. However, an increasing number of studies on this topic have been published since 2017. However, this data may be affected due to the COVID-19 pandemic, where experiences and literature on distance support and online intervention with students with visual impairment were non-existent (Battistin et al., 2021). In this sense, one of the main results that stands out is the scarcity of academic literature related to ICT and visual impairment at university.

Although studies on this topic in recent years have been scarce, it has aroused the interest of researchers worldwide. Thus, studies have been conducted in different countries, particularly in the Americas and Europe according to the databases analyzed. This may be because there is a very high prevalence of people with visual impairment in Latin America.

Predominantly (62.5%), the studies adopted a qualitative approach to analyze the impact of ICT tools on visually impaired students in higher education. There have been fewer quantitative (25%) or mixed methods (12.5%) studies.

*What are the findings regarding the impact of ICT on the education of students with visual impairment in higher education?*

To answer the second research question (PI2), related to the impact of ICT use on learners with visual impairment, the studies analyzed revealed two main categories: opportunities and challenges.

In terms of the opportunities described, the use of ICT facilitates access to information and communication for students with disabilities as well as encouraging learning and promoting this demographic's participation (Eligi & Mwantimwa, 2017). However, in the case of students with visual impairment, their use is difficult.

Studies have highlighted the different challenges students with disabilities face in achieving an adequate education using ICT, such as the limited availability of these resources in university institutions, the lack of teacher training and both technological and pedagogical accessibility to these tools (Alabi & Mutula, 2020). Therefore, based on these findings, this study offers the following essential points to avoid these obstacles:

- Availability of resources: University faculties emphasize that few devices are available to students with visual impairment in university institutions. Indeed, audiobooks or Braille texts are limited (Gill et al., 2017). However, more and more students have digital tools, such as mobile devices or computers, from which information can be accessed in real time, thus becoming tools to support the autonomy and independence of this group of students. Teachers must be able to harness the potential of these digital tools and provide visually impaired students with new opportunities to participate in the learning environment.

- Affordability: Although there are easily accessible resources, such as Window's JAWS screen reader for students who are blind or the ZoomText screen magnifier for students with low vision, in general, the original resources and software are too expensive, leading to the use of pirated versions.
- Accessibility (technological and pedagogical): Technologies can be classified into three groups: exclusive, assistive and invisible. Exclusive technologies are those that are not suitable for everyone. For example, the Braille system is not aimed at all visually impaired students so it may offer great benefits for some but not for others. There are also assistive technologies, which are aimed at all people regardless of disability, by universal design. We can include in this group screen readers (Alabi & Mutula, 2020), which allow learners to know what is happening on a screen without the need to see the screen. And finally, there are invisible technologies, that is those that disappear when used, such as automatic access doors to an establishment, as there are also architectural barriers that make it difficult for students with visual impairment to access university institutions (Cruz-Felipe et al., 2018). Compared to their peers, these students also present challenges in accessing the university library collection (Dodamani & Dodamani, 2019). In this regard, digital libraries have become an indispensable platform supporting access to written materials, which are perfectly readable and accessible by any student with screen reader software.
- System efficiency and usability: Software is often too slow or difficult to download, and resources have limited battery life. This creates many difficulties for learners in accessing information (Ahmed & Naveed, 2020; Menzi-Çetin et al., 2017).
- Training: Training, both of teachers and students, is scarce. The use of digital tools to support the learning process of students with visual impairment can significantly enhance their learning (Sokolov, 2019) if used appropriately. However, due to a lack of digital training, materials are poorly adapted or inappropriately used. For example, teachers enlarge the font of the materials but do not consider student fatigue (Gómez Santos et al., 2018). Meanwhile, a lack of experience and poor digital skills hinder the use of ICT for learners with visual impairment (Ahmed & Naveed, 2020).

Despite the many problems encountered, ICTs have made access to higher education possible for visually impaired students. The purpose of identifying the different difficulties related to the use of ICT is to be able to adapt these tools to make education more inclusive, eliminating the technological, psychological, social and architectural barriers presented by this demographic

(García Cedeño et al., 2016; Luque Colmenero et al., 2015). Based on these findings, it is recommended that higher education institutions ensure accessibility for students with visual impairments (Kisanga & Kisanga, 2020; Villalobo et al., 2018).

*PI3. What are the emerging themes in the research pertaining to the use of ICT for visually impaired learners in higher education?*

The bibliometric maps allowed us to locate and identify the central and emerging themes in this field of research, thus answering the third research question. The following research themes emerged:

1. Studies related to the opportunities to access to higher education for students with visual impairment. This line of research has focused on the educational needs of this group of students. However, we must bear in mind that visual impairment is not a unitary construct. Therefore, the needs of blind students are very different from those with low vision. Therefore, it is recommended that researchers continue developing studies that address the educational needs of students with visual impairment according to whether they have low vision or blindness.
2. Studies related to the experience and perceptions of access to higher education of students with visual impairment. This set of studies examines the experiences of this demographic as well as the barriers that hinder their access to university. In this line of research, the lack of training on the part of university lecturers is noted. Additionally, the issue of ICT training courses to support students with visual impairment has received little attention (D' Andrea & Siu, 2015; Palan, 2021).
3. Studies related to the type of ICT tools used by visually impaired university students. This is an emerging topic within the field and is still developing. Consequently, it is recommended that researchers continue developing studies to consolidate lines of research on the type of technological tools available in higher education for students with visual impairment.

As observed, this study offers a descriptive and analytical overview from both diachronic and synchronic perspectives of the main bibliometric variables in four of the databases with the greatest impact on the scientific community. Therefore, it allows both university professionals, researchers and higher education institutions to visualize the most developed study trends and emerging lines of research to advance the educational improvement of students with ICT-mediated visual impairment.

## Conclusions

This study presents a systematic review to provide an overview of the impact of ICT on students with visual impairment in higher education contexts.

The review of the 17 articles shows that ICT is considered in teaching–learning processes with visually impaired students. These technologies allow students to access digital information on computers, tablets or mobile phones, thanks to the installation of software or applications, such as screen readers, screen magnifiers or the Braille line. They have also become an essential means through which students with visual impairment can learn and access learning materials (Mokiwa & Pasha, 2013; Cortaza-López et al., 2018).

However, it should be questioned whether the use of these tools and software is sufficient for students to access the information presented in a virtual environment. The documents presented must comply with accessibility conditions. In this sense, teachers are an indispensable element in offering quality education to students with visual impairment. However, the limited training of university teaching staff in digital competencies is a barrier to the development of inclusive education (Aquino-Zúñiga et al., 2016).

*What can we do?*

So that digital tools do not become a barrier to the learning and participation of this group of students, it is recommended that teachers have initial and ongoing training on the application of ICT to students with visual impairment (Gómez Puerta & Chiner, 2019). This would enable teachers to develop accessible activities according to international standards and provide lesson material in a digital format adapted to the guidelines set out in the Sustainable Development Goals, Universal Design for Learning and W3C standards.

We need to make an additional effort to overcome the barriers cited above (Gill et al., 2017) to enable students with visual limitations to access the same information and acquire the same knowledge as their peers (Boulbaba Othamni et al., 2018; Loyola & Viada, 2018).

*Limitations and future research*

Several limitations were encountered while conducting this review, as numerous publications address the implementation of ICT in the education of students with disabilities, but those that focus specifically on the impact on students with visual impairment are scarce.

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