Impact of the Information and Communication Technologies on the Education of Students with Down Syndrome: A Bibliometric Study (2008-2018)

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Abstract: This article analyzes the impact of the Information and Communication Technologies (ICT) on students with Down syndrome through the consult of scientific articles published during the 2008 to 2018 period, in five scientific journal databases utilized in the academic world. Through a descriptive and quantitative methodology, the most significant bibliometric data according to citation index is shown. Likewise, a methodology based on the analysis of co-words and clustering techniques is applied through a bibliometric maps, in order to determine the fields of scientific study. The results show that articles published have a medium-low index of impact. There are linked with the importance of using ICT with these students, from educational inclusion and accessibility perspective.

Keywords: *ICT, Down syndrome, disability, indexations, bibliometric study.*

Introduction

The Information and Communication Technologies (from here, ICT) contribute to scientific development, increasing the quality of life. They enhance activities in the daily life of anyone, particularly with persons with disabilities. The use of technologies contribute to their having a more autonomous or independent life, helping to overcome cognitive, sensorial and motor limitations. In order to guarantee the equality of employment opportunities in the use of the ICT for people with disabilities, different initiatives have been developed in the past few years, such as: the "European Disability Strategy 2010-2020: A renewed commitment to a Barrier-Free Europe", or the "Global Initiative for inclusive information and communication technologies", from the Global Alliance for Information and Communication Technologies and Development- At the Latin American level, the Organization of Ibero-American States (OEI), in its 2021 Goals, promote "fomenting that high quality ICT, ensuring their sustainable access for persons with disabilities".

The ICT provide an essential support for a comprehensive training of people with disabilities in general and with Down syndrome in particular (training, social relationships, employment, etc.). Nowadays, this topic has become an emergent field of study, thanks to technological resources,. Thus, by using Google Trends (a tool that has the ability to analyze the "what", "when", "how much" and "where" the searches are conducted through its search engine), and analyzing the search frequency of the term "Down Syndrome" and "ICT" in the world in the last ten years, a constant figure has been observed in the search percentage. This growth is more evident in the academic area. In fact, a quick-search including the following terms "ICT and Down Syndrome" in Google Scholar provided 778 results between 1988 and 1998, 5790 from 1998 to 2008 and 17000 from 2008 to 2018. It is possible that not all of these articles are directly related to the use of the ICT and Down syndrome. However, the big quantity of documents identified suggests that there is a growing number of literature that has awoken the interest on the subject matter.

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Research on ICT and Down syndrome

At present, persons with Down syndrome are growing along with technologies. However, the understanding about how the ICT can truly have an impact on their education and their development is very scarce, despite the evolution of these technologies in the last few decades (Passey, 2013). In addition, the existing research on the subject of students with disabilities in general is very little developed. This is particularly noticeable when one compares broad framework developed about the ICT and students in general. On the other hand, this could be due to the fact that the scarce existing research about persons with special education needs has a strong theoretical character, needing empirical research designs (Periathiruvadi & Rinn, 2013) that advance new exploration areas.

In this regard, Istenic and Bagon (2014) showed results from a content analysis of all articles published from 1970 to 2011 in seven educational technology journals indexed in Web of Science (WoS), where the scarcity of research papers related to the ICT and disability were highlighted. Damianidou, Arthur-Kelly, Lyons and Wehmeyer (2018), in a meta-analysis of published studies on people with intellectual disability until 2003, concluded that more investigations were needed in order to explore the impact of the different types of technology on this collective.

Thus, the scarcity of the bibliographic reviews related to the ICT and the students with Down syndrome could be motivated, on the one hand, to the lack of research conducted on ICT and disability, and on the other, in that the research on students in general can exclude those who have some type of disability (Connors & Stalker, 2007).

Some bibliometric studies on the ICT about the education of persons with Down syndrome have been conducted in the last few years, such as the one conducted by Pazos, Raposo and Martinez (2015), on 4 databases (Scopus, ERIC, Google Scholar and Dialnet) between the years 2000-2014. Here, authors highlighted that reading and writing area was the most identified area by literature, followed by the teaching of mathematical skills and the learning using ICT. The study highlighted that the most-utilized ICT resource in these studies was the computer (80%), and only 8% were focused on the use of mobile devices.

Despite the interest of society and the scientific community for disability, more research is needed in order to understand the best manner in which to adapt the technology to the requirements and preferences of the students with Down syndrome (Dixon, 2011). In this regard, the main objective of the present study is to conduct a bibliographic review, using a quantitative and qualitative methodology, on the studies published from 2008 to 2018 on the ICT applied to students with Down syndrome. We believe it important to conduct a research study that analyzes the different variables in depth, both bibliometric as well as thematic, in order to place the researchers and those interested on the ICT applied with persons with Down syndrome, before an up-to-date panorama of the scientific repercussions from different variables and study perspectives, that allow the detection of difficulties, weaknesses and the incorporation of new challenges.

We believe this type of bibliographic review study is important, as the concept "bibliography" has been acquiring a more relevant importance in research field (Friedlander & Bessette, 2003). Likewise, this scientific research can be measured in a more reliable manner by analyzing the number of publications (productivity) and the frequency of citations of these works (visibility) (De Moya et al., 2010).The bibliometric indicators allow for the analysis of the scientific production in a quantitative and qualitative manner, meaning, their repercussion (Velasco, Eiros, Pinilla & San Roman, 2012). The use of these indicators allow for the precise characterization of the state of development of the research, thereby substantiating the making of decisions on scientific policies (Cunningham, 1997).

Purpose and research questions

The study has a two-sided objective:

On the one hand, to bibliometrically quantify, in the Web of Science (WoS), Scopus, Google Scholar, Education Resource Information Center (ERIC) and SciELO databases, the scientific production on ICT applied to students with Down syndrome, in the shape of scientific articles, during the 2008-2018 period. The following variables will be analyzed: total number of published articles; number of citations received; main citing journals; average cites per year; name, country, and institutional affiliations of the most-cited authors and the methodological focus of the articles. On the other hand, to analyze the keywords used in the articles in order to establish the thematic and conceptual implications with which the researchers are making advances on the comprehension and analysis of the ICT as support for disability.

The following research questions are explored:

Q1: What is the general state of research on the field of ICT as support for students with Down syndrome?

Q2: What countries and journals have the most articles published?

Q3: What are the main lines of research within the domain of the ICT and people with Down syndrome?

Q4: What research designs predominate in this domain?

Methodology

Description of the research

The research is characterized for being a systematic review of the literature, starting with the standards found in the bibliometric studies in the field of education (Fernandez & Bueno, 1998), with the use of descriptive, quantitative, correlation and semantic application techniques to the study of keywords with the analysis technique of social networks (Knoke & Yang, 2008) through the use of visual representations with the software VOSviewer. The comparative use of databases is a method used in research studies that measure the impact of a term or trend (Levine-Clark & Gil, 2009).

Procedure for searching, identifying and selecting articles

The electronic search of articles (computer-supported literature search) was conducted in the following online databases: Web of Science (WoS), Scopus, Google Scholar, Education Resource Center (ERIC) and SciELO.

The criteria for inclusion were: the studies were considered only if: a) the search descriptors were specified on the title, keywords and/or the abstract; (b) they were published in English or Spanish; (c) they were published in periodic journals or publications that were peer-reviewed; (d) they were related to the field of Education; and (e) addressed the students with Down syndrome in any educational stage. With respect to the exclusion criteria, the following research studies were eliminated: (a) publications whose entire text was not available; (b) scientific articles (abstracts, theses, dissertations, books, conference proceedings and technical reports) published in non-periodic publications; (c) studies on students with Down syndrome outside of the educational context, and (d) duplicate articles.

For the analysis, the bibliographic data from the articles were quantified, obtaining indicators that had also been used in other bibliometric studies. These were related to: authors, countries, institutions and thematic areas (Chiu & Ho, 2005; Lopez, Vazquez & Roman, 2015). Afterwards, an analysis of word frequency was conducted (Bhattacharya, Kretschmer & Meyer, 2003; Ding, Chowdhury & Foo, 2001) with special attention to the analysis of co-occurrence within the specific research domain of students with Down syndrome and technologies. With a similar focus, different scientific disciplines have shown success in its application (Cahlik, 2000; Neff & Corley, 2009; Viedma, Perakakis, Munoz, Lopez, & Vila, 2011). Initially, we use the following descriptors from ERIC thesaurus to start the search: «Down Syndrome» and «ICT»; «Down Syndrome» and «digital»; «Down Syndrome» and «technology»; «Down Syndrome» and «Information and communication technology»; «Trisomy 21» and «ICT»; «trisomy 21» and «digital» in Web of Science, Scopus, Google Scholar, ERIC and SciELO, selecting the articles that were related to this topic.

The extraction of data was performed through a direct access to databases, taking into account the following variables: total number of articles; number of citations received by each article; journals that cited articles on ICT and Down syndrome; authors; institutional affiliation of the authors; productivity according to country; focus of the article (theoretical, quantitative, qualitative and mixed); distribution of the article according to topic analyzed; distribution of the articles according to technologies employed, and relevance of the content, through keywords in Web of Science, Scopus, Google Scholar, ERIC and SciELO: word clouds through the creation of a .txt file (in the case of WoS) and .csv (in the case of Scopus, Google Scholar, Eric and SciELO), and their visual representation (VOSviewer program).

The results of this investigation will be reflected below.

Results

In a first bibliographic search, a total of 1494 publications were retrieved, 963 being extracted from Google Scholar, 115 from Education Resource Information Center (ERIC), 42 from SciELO, 113 from Web of Science (WoS) and 261 from Scopus taking in to account the search criteria cited above.

In a first screening, we exclude 298 duplicate documents. After that, there meaning 1196 documents were analyzed, having the exclusion criteria. Thus, 376 were eliminated for not being available, 393 due to the type of document (doctoral dissertations, books, communications, conference proceedings and technical reports); 54 items for being published in a different language from Spanish or English. Also, 217 documents were removed for including students with Down's syndrome within the educational context.

Finally, 156 articles were selected, including 72 from Google Scholar, 17 from ERIC, 6 from SciELO, 24 from WoS and 26 in Scopus. Next, a flow chart is presented, following there commendations of the PRISMA declaration (Preferred Reporting Items for Systematic reviews and Meta-Analyses), including identification, screening, suitability and inclusion criteria.
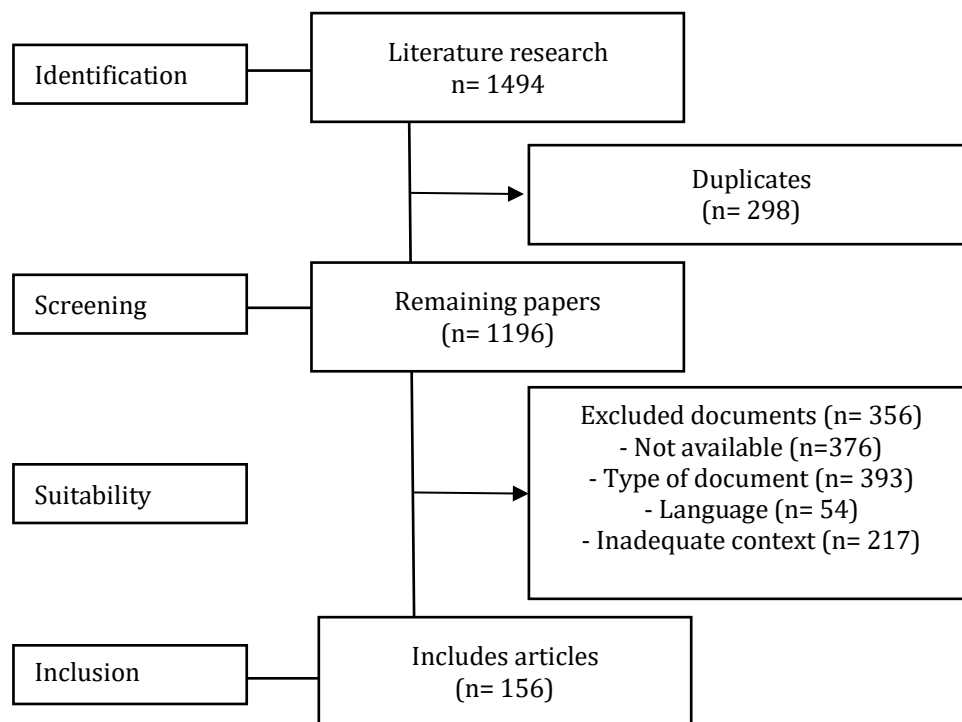
Figure 1. Sample flow chart

The results are presented in two sections. In the first section, the quantitative data from the analysis of the five databases will be presented in order to answer the first objective of our study. In the second section, the figures of keywords from databases, along with their analysis will be presented, to identify the main implications in the study of students with Down syndrome and the ICT, according to the themes studied.

Table 1 shows the number of articles published in the 2008-2018 period in the five databases analyzed. The articles published in the the highest impact and international prominence databases (WoS and Scopus) were lesser in number as compared to the other three ones (Google Scholar, ERIC and SciELO).

Table 1. Number of articles in the different databases

Year of Publication	Number of articles				
	Scopus	**WoS**	**SciELO**	**ERIC**	**Google Scholar**
2008	0	1	0	1	3
2009	0	3	0	1	4
2010	3	0	0	2	9
2011	1	1	0	3	5
2012	0	0	0	2	5
2013	1	1	0	3	9
2014	1	1	1	1	12
2015	4	3	4	0	10
2016	3	2	0	1	4
2017	10	8	1	3	6
2018	5	5	0	1	5
Total	28	25	6	18	72

These articles were randomly distributed among the different quartiles of the corresponding databases. The greatest number of articles was found in 2014 in Google Scholar (n=50) and in 2015 in SciELO (n=4). In the case of ERIC, WoS and Scopus, the greatest numbers were registered in 2017, with 3, 8 and 10 publications, respectively. Likewise, the decrease in the number of citations of the articles in every database starting in 2014 was significant, as not many of them received more than 1 citation.

Table 2. Number of articles cited per year

	Database																													
	2008-2013					2014					2015					2016					2017					2018				
Citations	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	0	0	0	4	0	0	1	1	0	0	1	1	4	0	0	1	1	0	0	0	7	5	1	0	3	5	5	0	1	3
1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	1	1	0	1	0	3	0	0	0	0	0	2
2	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0
3	0	0	0	1	3	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
6	0	0	0	1	3	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
8	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0
10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>10	5	4	0	5	25	1	0	0	0	4	0	0	0	0	3	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0
Total	5	6	0	12	35	1	1	1	1	12	4	3	4	0	10	3	2	0	1	4	10	8	1	3	6	5	5	0	1	5

Note: 1= Scopus; 2=WoS; 3=SciELO; 4=ERIC; 5=Google Scholar

The impact of the citations of the authors in each article related to the ICT and Down syndrome in the different databases was very low. This implies that articles related to ICT and students with Down syndrome in the different high impact databases were still not very significant. Thus, authors who had the most citations in the different databases were: Wuang, Y.P. with 507 citations in Scopus, 442 in WoS, 402 in ERIC, 0 in SciELO and 609 in Google Scholar; followed by Chiang, C.S. (92=Scopus, 85=WoS, 132=ERIC, 0=SciELO, 191=Google Scholar), Van Bysterveldt, A.K. (73=Scopus, 36=WoS, 59=ERIC, 0=SciELO, 231=Google Scholar), Felix, V.G. (43=Scopus, 22=WoS, 0=ERIC, 0=SciELO, 64=Google Scholar) and Ayres, K.A. (26=Scopus, 18=WoS, 23=ERIC, 0=SciELO, 105=Google Scholar).

It was verified that the five articles with the most citations (after eliminating self-citations) in both databases had a focus that was eminently empirical, and that studied the learning of students with Down syndrome through the use of the ICT (Table 3). Likewise, it was proved that the research on «ICT and Down Syndrome» is still in the initial stages. Actually, there are not many studies that focus in the scientific-academic area of Down syndrome.

Table 3. Most cited articles about ICT and Down syndrome

Title of article	Authors	Journal	Year	Citations				
				1	2	3	4	5
Effectiveness of virtual reality using Wii gaming technology in children with Down Syndrome	Wuang, Y.P., Chiang, C.S., Su, C.Y. & Wang, C.C.	Research in developmental disabilities	2011	80	63	0	55	175
Computer usage by children with Down Syndrome: Challenges and future research	Feng, J.A. Lazar, J.A., Kumin, L.b., Ozok, A.C.	ACM Transactions on Accessible Computing	2010	41	0	0	0	85
Computerized memory training leads to sustained improvement in visuospatial short-term memory skills in children with Down Syndrome	Bennett, S.J., Holmes, J., Buckley, S.	American Journal on Intellectual and Developmental Disabilities	2013	33	29	0	30	58
Wayfinding behaviour in Down syndrome: A study with virtual environments	Courbois, Y., Farran, E.K., Lemahieu, A., Blades, M., Mengue-Topio, H. & Sockeel, S.	Research in Developmental Disabilities	2013	21	18	0	15	40
Investigating input technologies for children and young adults with Down syndrome	Hu, R., Feng, J., Lazar, J. & Kumin, L.	Universal Access in the Information Society	2013	12	8	0	0	24

Note: 1= Scopus; 2=WoS; 3=SciELO; 4=ERIC; 5=Google Scholar

Therefore, data on the methodological focus of the article is valuable information that provides us with a general perspective on the nature of the research and observations on the studies on ICT and students with Down syndrome in this initial and expansion phase. The results obtained showed that until the present, most of the research was focused on the articles of quantitative and qualitative methodology, followed by theoretical articles on observations and trials in all the databases. [Insert Table 4 about here]

Among the countries that were most active during the last few years, the UK was noted with 6 documents in WoS, 5 in ERIC, 3 in Scopus, 1 in SciELO and 15 in Google Scholar; Brazil (WoS=3; Scopus=3; SciELO=3; ERIC=0; Google Scholar=4); the U.S.A. (WoS=5; Scopus=4; SciELO=0; ERIC=4; Google Scholar=13); Spain (WoS=4; Scopus=3; SciELO=1; ERIC=3; Google Scholar=13) and Germany (WoS=3; Scopus=2; SciELO=0; ERIC=2; Google Scholar=10). Therefore, within the set of universities and institutions with the greatest production of scientific articles on the study of the ICT and students with Down syndrome, the European and North American universities were notable, with special emphasis on the research institute «Berlin Institute for Social Research» (WoS=1; Scopus=1; SciELO=0; ERIC=1; Google Scholar=2).

The ten journals with the highest index of citations were published for the most part by English, Brazilian or American institutions, mainly represented, according to production, by journals such as «Research in Developmental Disabilities», «Revista Brasileira de Educacao Especial» and «Journal of Special Education Technology». The Spanish journal «Digital Education Review» is notable among this group. In regards to the subjects that were more studied in the articles reviewed, related with the «ICT and Down syndrome» in these databases, it was found that the development of motor skills was the most-studied area (18.10%), followed by the development of reading-writing skills (16.19%) and those that referred to the development of communication and language (15.24%). We should also highlight the works that

addressed the personal development and autonomy of the students with Down syndrome (14.29%) and on the access and use of ICT tools (10.48%). Lastly, and not less important, works related to the teaching of mathematical skills (10.48%) appeared, along with learning of memorization strategies (7.62%), as well as those related to the acquisition of healthy habits and hygiene of students with Down Syndrome (5.71%) and music (3.81%).

On the other hand, as for the distribution of the articles reviewed according to the types of ICT resources that were most-utilized to work with students with Down Syndrome, those that used educational software (42.31%) were notable, followed by computer programs (23.34%). These were followed closely by research studies that employed virtual reality software (21.59%). Lastly, those that used Web resources or the use of the Internet (12.76%) should be noted.

As for the types of ICT tools and supports that were most utilized in the articles reviewed diverse categories were established. Thus, in the last 10 years, the ICT tools that were most employed with students with Down syndrome were computers (42.70%), as these were mainly used for educational programs or for learning about their use or about them in general. It should also be noted that there were also research studies that utilized smartphones (20.22%), followed by videogame consoles (14.61%), meaning, the videogames from PlayStation (Sony), Xbox One (Microsoft) or Wii (Nintendo) were utilized as innovative tools for working with the motor skills of these students.

Once the descriptive and quantitative analysis on the impact of these studies about ICT and students with Down syndrome within the selected databases was conducted; and in order to identify possible research trends and directions over the last decade, an correlation analysis was conducted of the relationships that were established between keywords, through their graphical representation. Once the file was loaded, the «Key-Words Plus (KW+)» field was used. These are keywords that were automatically extracted from the documents, and were used as the basis for obtaining the network of words.

Thus, after the analysis of the selected databases, 28 documents were collected from Scopus, 25 from WoS, 18 from ERIC, 6 in SciELO and 72 in Google Scholar, which corresponded to the complete 2008-2018 period, as previously mentioned (Table 1), from which a total of 85KW+ words were obtained, with a frequency ≥10. After analyzing the homogeneity of the KW+, topic clusters were created according to the degree of similarity of the KW+. In this case, 5 clusters were found, within which we could observe the weight each descriptor had within the network according to the dimension of the node that represented it and their links as well, meaning the relationships exchanged by each node through a straight line.

Figure 2. Tagged bibliometric map, where the 85KW+ analyzed are represented

In the tagged bibliometric map (figure 2), the size of the clusters is determined by different factors, such as the number of KW+ inside the clusters or the frequency of occurrences of the KW+. Each cluster is distinguished by a color in a random manner. The clusters found in the center of the map indicate a high correlation of the KW+, while those place on the edges of the map indicate a smaller interrelation. The size of the tag is also proportional to the frequency of appearance. As the result of the tagged bibliometric maps shows, 4 topic clusters were obtained, which defined the main currents of research on the ICT studies and the students with Down syndrome.

Cluster 1: related to the students with Down syndrome and their main characteristics. This cluster was also focused on the importance and benefits contributed by the ICT to these students. This red-colored cluster grouped 16 items such as: Down syndrome (weight=145), skill (weight=22), student (weight=12).

Cluster 2: related to the types of ICT instruments and resources used in the classroom with students with Down syndrome. In this line, the main part of the present study was found, meaning, the importance of the use of these technologies in society and in education. The green-colored cluster grouped 29items. Some of these were: game (weight=30), technology (weight=24), computer (weight=12).

Cluster 3: related to the main topics studied in the classroom with these students, related with their interests and characteristics. This blue-colored cluster was comprised by 19 items, such as: functional mobility (weight=8), reading (weight=7), memory (weight=5).

Cluster 4: related with inclusive educational practices, teacher's training on this topic and the participation of the family. This yellow cluster grouped 21 items. The most notable ones were: intervention (weight=14), evaluation (weight=7), teacher (weight=4).

A density bibliometric map was also created, obtained from the analysis of the databases, where the size of the KW+ tags and the color of the different areas indicated their level of relevance (Figure 3), highlighting the following nuclei:

In the central zone of the maps (yellow color) the KW+ belonging to the research line related to the inclusion of the ICT at school with the students of Down syndrome (Down syndrome, inclusion, technology) were found here due to their importance and co-occurrence. The colors next to the yellow show the areas of greater density of co-occurrences of KW+.

In the peripheral area of the map (color next to the green color), the KW+ that referred to the main topic studied and the ICT tools that were most utilized with these students in the classroom, were located. In the upper part, we can find items such as: methodology, Smartphone, mathematics, and in the lower part other items such as: virtual reality, program, physical activity. The areas next to the green area show areas of lesser density of co-occurrences of KW+.
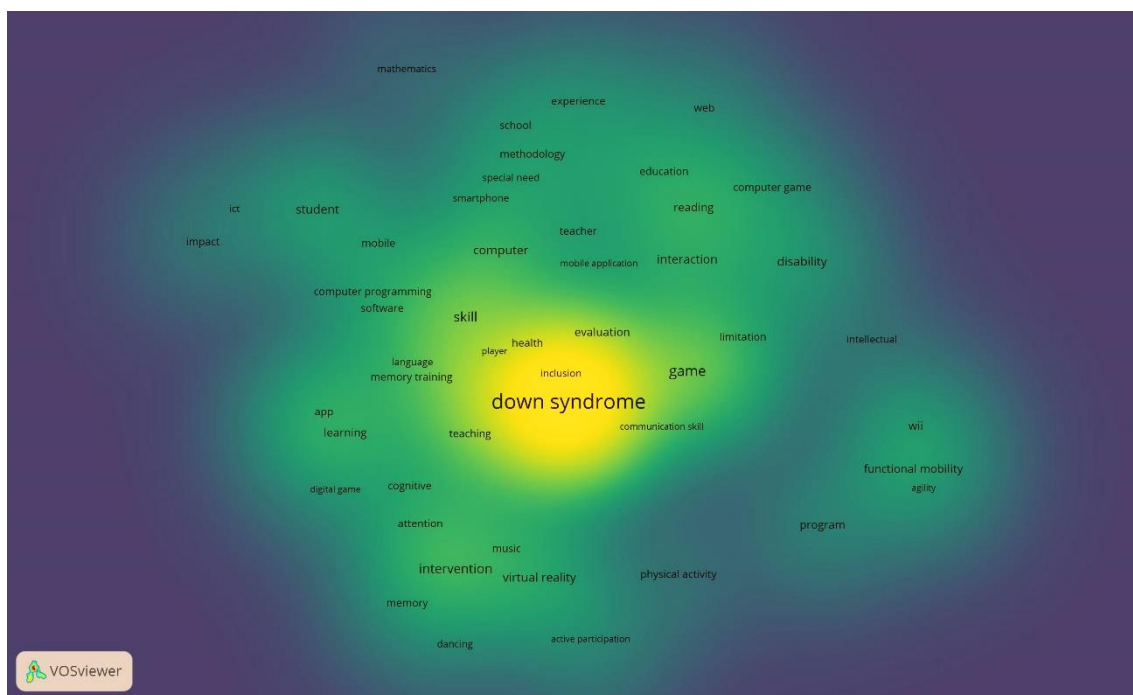

Figure 3. Density bibliometric map where the 85KW+ analyzed are represented

Discussion and Conclusion

Regarding the first research question (P1), concerning the overall state of research in the area of ICT as support for students with Down syndrome, the main conclusion is that the high-impact scientific production in the last ten years (2008-2018) is still not well-developed. The number of articles published in journals indexed in WoS and Scopus, Google Scholar, ERIC or in SciELO is low compared to other topics and emergent fields of research. This is a problem for research about ICT and Down syndrome, mainly for the teacher's training, as for the efficient integration of ICT in teaching and learning processes. Then, emergent lines of research are needed that can be incorporated into study plans and programmes, both pre-service teacher training and ongoing teacher training. These findings share Dixon's (2011) reflections, testifying that more research is needed to understand how the technology can be adapted more effectively

for the needs and preferences of children with Down syndrome. With regard to the second research question (Q2), which was aimed at identifying the countries and journals with the highest published articles, the European and North American universities had the greatest scientific impact, particularly UK and USA. As for the journals that were more notable due to their production of articles in this area of knowledge, these were English, Brazilian or American, highlighting journals such as «Research in Developmental Disabilities», «The Brazilian Journal of Special Education» and «Journal of Special Education Technology».

The main research line within the domain of the ICT and students with Down Syndrome (Q3), through the visualization of the tagged bibliometric map, allowed us to extract a series of conclusions. First, the map revealed that on the period analyzed, the studies on the ICT and Down syndrome are being thematically linked with the importance of the use and the management of the ICT with these students. Second, an emergent topic group related to the educational inclusion of students with Down syndrome and the use of the ICT was observed. Third, it was noted that most of the studies were focused on the use of the computer (Eckhaus & Davidovitc, 2019; Osei, Liang, Natalia & Stephen, 2016; Pazos et al., 2015) and the Smartphone as tools. Likewise, the most-utilized resources were educational software and computer programs. Fourth, the topics that were most worked on were reading-writing, communication and language, and motor skills. These findings coincided with those by Pazos et al. (2015), as regards to the topic that was most researched, such as reading and writing. On the other hand, communication and language did not appear in the previous study as focus of attention. And fifth, in this period, an interest in research related to the knowledge and training of the teachers with respect to the use of the ICT and this type of student, was not detected. Along this line, it should be said that professional development was a non-emergent thematic area, which was a contradiction, as no matter how good a technological tool is, its effectiveness for the teaching of students depends on how these teachers use and integrate the technology in the curriculum. Thus, here lies the need to promote a greater training of teachers.

The analysis of the results from the density bibliometric map showed as predominant terms (core-terms) during 2008-2018 period, the following: inclusion, methodology, Smartphone, mathematics, virtual reality, program, physical activity. It was observed how the virtual environments started to garner the attention by part of the researchers, as they brought important possibilities of improvement in the learning and communication of persons with Down syndrome. Augmented reality, as well as virtual reality in the shape of Serious Games, constituted an emergent field of study. A greater digital literacy, together with the acquisition of protocols of usability that are specific for these students, are key elements to overcome digital barriers that exists between healthy individuals and those who suffer from intellectual disabilities.

As for the question that referred to what research designs predominated (Q4), it could be concluded that the findings obtained showed that up to the present, most of the research had been focused on qualitative and quantitative methodology articles, followed by theoretical ones based on reflection and trials. Thus, the methodological focus of the articles published in the five databases had a highly qualitative character.

Lastly, regarding the areas could be addressed in future research studies (Q5), it should be stated that ICT should not only be oriented towards satisfying learning needs, but also the student's social and emotional needs. Thus, the ICT should contribute not only to the development of their cognitive abilities, but also affective and social ones.

For future studies, the construction and comparison of bi-dimensional bibliometric maps corresponding to different time periods could indicate the direction of these research trends and directions on ICT and Down syndrome.

Limitations

The study had some limitations that should be taken into account before making decisions on the use of technological tools with these students. This review did not adequately compare or contrast the effectiveness of technological tools that were specific for them. This limitation was due in part to the scarcity of research studies and the scarce dissemination of empirical studies throughout a decade of research in this area. Other limitations derive from the elimination of abstracts, dissertations, books, conference proceedings and technical reports published in non-periodical publications, may slightly inhibit possible advances in this field.

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