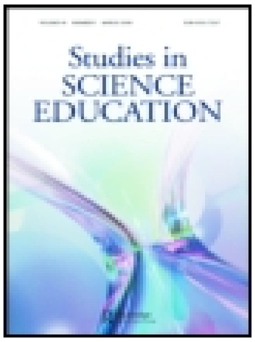

Studies in Science Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rsse20

A bibliometric and descriptive analysis of inclusive education in science education

Michele Waltz Comarú, Renato Matos Lopes, Luiza Amara Maciel Braga, Fabio Batista Mota & Cecília Galvão

STUDIES IN SCIENCE EDUCATION
https://doi.org/10.1080/03057267.2021.1897930

REVIEW ARTICLE

A bibliometric and descriptive analysis of inclusive education in science education

Michele Waltz Comarú [a,b,c], Renato Matos Lopes [b,c], Luiza Amara Maciel Braga [d], Fabio Batista Mota [d] and Cecília Galvão [c]

[a]Instituto Federal Do Rio De Janeiro, Campus Mesquita, Mesquita, RJ, Brasil; [b]Laboratório De Comunicação Celular, Instituto Oswaldo Cruz, Rio De Janeiro, RJ, Brasil; [c]Instituto De Educação Da Universidade De Lisboa, Alameda Da Universidade, Lisboa, Portugal; [d]Centro De Estudos Estratégicos Da Fiocruz, Rio De Janeiro, RJ, Brasil

ABSTRACT

This article aims to map the scientific production concerning the inclusion of people with disabilities in Science Education to promote a reflection on the production of this area. Bibliometric analysis is used to help understand what stage of research a particular subject is at. Publications on the topic indexed at the Web of Science Core Collection (WoS) were evaluated. A total of 119 articles published between 2009 and July 2019 were selected as dealing specifically with the subject. An increase in the number of articles associating Science teaching (ST) and Inclusive Education (IE) was noted. The journals that published the most, the most productive authors in the area and their collaboration networks were identified. A content analysis of the research was also carried out and the main investigated topics were pointed out. Educational levels, types of disabilities, central themes and specific science areas prevailing in the mapped research were also indicated. We conclude that, despite the growing number of articles, scientific production associating SE and IE is still small, concentrated, and not shared with the scientific community through scientific education journals, and that most research is focused on the use of methodologies and resources, and not on their development.

ARTICLE HISTORY
Received 1 May 2020
Accepted 13 January 2021

KEYWORDS
Science education; inclusive education; students with disabilities; nature sciences; bibliometrics; network analysis

Introduction

Teaching people with disabilities in Science Education has become an urgent approach in the last decade, not only due to the quantitative increase of this type of student in regular classes stimulated by inclusion policies (Comarú et al., 2014; Jitendra et al., 2002; Lid, 2015; Zagrai et al., 2017), but also due to the understanding that the experience of teaching to people with disabilities promotes important changes (especially methodological, but also concerning other aspects) in the way science is traditionally taught (Brigham et al., 2011; Joyce et al., 2020; De Leo-Winkler et al., 2019; Mastropieri et al., 2006). These changes must and have been studied in the science teaching research context so that successful practices and challenges can be reflected and discussed among peers (Anderson et al., 2018).

CONTACT Michele Waltz Comarú michele.comaru@ifrj.edu.br

In general, science teachers maintain positive attitudes and are willing to adapt and/or change their teaching methods to create an inclusive classroom context and understand that natural sciences contents are a part of students literacy and citizenship training in a broad manner (M. G. Villanueva & Hand, 2011). However, studies indicate that they feel a lack of support and continuous guidance to aid them in deciding and understanding the pedagogy, methodologies and technological resources appropriate to meet student needs (Mutch-Jones et al., 2012; De Sousa et al., 2018; Spektor-Levy & Yifrach, 2019). It is in this sense that academic production can contribute to subsidise practices, promote exchanges and support teachers in everyday teaching, while also clarifying new science education scenarios. Thus, knowledge on scientific literature discussions regarding the relationship between education for students with disabilities (SPD) and Scientific Education (SE) becomes valuable. In addition, knowledge on researcher networks, the most covered subjects, journals and the most cited articles, reveals an overview of how researchers in the SE area have conducted research on inclusive education (IE).

Mapping studies, such as systematic literature reviews, meta-analyses and bibliometric and network analyses, are important tools that aid in better understanding specific conceptual cuts in the context of large areas of scientific production. Specifically in SE, studies of this nature have already been carried out to investigate, for example, Universal Design for Learning and STEM (Schreffler et al., 2019); science teaching for students with intellectual disabilities and/or Autism Spectrum Disorder (Apanasionok et al., 2019); how secondary school characteristics, such as schools' academic press and school climate, provide opportunities for students to engage in science and maths (Holzberger et al., 2020); research-based practical work and its challenges in science education (Akuma & Callaghan, 2019); change in instructional practices used in undergraduate STEM courses (Henderson et al., 2011); and several other special topics within a general science education context. Most studies were conducted in the form of systematic reviews, in which the focus is applied on understanding how a given subject has been discussed in the scientific literature, which leads to the so-called 'state of the art'.

In addition to identifying the most widely discussed subjects, bibliometric analyses seek to identify the authors who produce the most, their institutions and the cooperation networks established to investigate a certain topic. According to Hayashi (2012), metric information studies, like Bibliometrics, Scientometry, Informetrics and Webometry constitute an interdisciplinary field aimed at the quantitative study of science and serve to evaluate the production generated by the scientific community in each area of knowledge. This production can be represented by articles, books, book chapters, works published in scientific event annals, and patents (Hayashi, 2012). Thus, studies of this nature allow for the understanding of the stage at which a certain research topic is at, as well as trends and statistical variations in production volume and the most cited references, thus contributing to the understanding of the research context of a certain subject. For example, Arici et al. (2019) carried out a bibliometric analysis on the use of augmented reality in science education and noticed a trend for research to focus on mobile learning environments and e-learning in the most recent assessments (Arici et al., 2019). In another study, the relationship between educational research and the use of the social network Facebook was investigated, revealing scientific production growth on this subject since 2008 (Lopes et al., 2017).

Bibliometric studies use mathematical and statistical methods to analyse scientific publications (Thompson & Walker, 2015). They indicate, for example, the development and growth of a research field (Dehdarirad et al., 2015). Bibliometric techniques can be used to generate a broad set of information aimed at analysing publication data. This includes, for example, the most relevant authors, research organisations, and countries producing knowledge on a given scientific field, the evolution of publications over time, and the main journals contributing to the dissemination of research results. The research areas in which publications are assigned can also be identified, which aids in understanding the main subjects addressed in publications. Another common information provided by bibliometric studies comprises the most cited references in a particular set of publications. This type of information can aid in understanding the theoretical roots of a given scientific field.

For its part, Social Network Analysis (SNA) is based on mathematical theory and graph theory. It applies models in the study of network structures to explain social processes (Kothari et al., 2014). It, thus, helps in identifying key research groups and prominent scientific publication authors (Jan & Vlachopoulos, 2019). Through a co-occurrence analysis between variables, SNA can identify the central authors, research organisations, and countries of a given network, as well as the main research collaborations. This type of information allows the identification of both the flow of knowledge among the relevant agents invested in the advancement of scientific knowledge and the results of the research they carry out in collaboration.

Both methods have been used together to map how scientific fields have evolved (Zupic & Čater, 2014). They have also been used in the analysis of education fields (Dehdarirad et al., 2015; Jan & Vlachopoulos, 2019). Both bibliometry and SNA differ from meta-analysis and systematic literature reviews, which are also aimed at analysing a relatively large amount of scientific information to provide an understanding of the research produced so far, as well as to discuss future trends and perspectives.

A meta-analysis is an evidence-based, quantitative synthesis of research results (Gurevitch et al., 2018), and a systematic literature review is a 'systematic way of collecting, critically evaluating, integrating, and presenting findings from across multiple research studies on a research question or topic of interest' (Pati & Lorusso, 2017). The difference between them is that the latter summarises and critically assesses a set of studies in a given context to draw evidence-based conclusions, while the former refers to the statistics used to gather the results of a systematic review (Akhter et al., 2019). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA Statement) is perhaps the best-known evidence-based guide of items for reporting literature systematic reviews and meta-analyses (PRISMA Statement: prisma-statement.org/).

These methods differ from bibliometrics and SNA for several reasons. For example, bibliometrics and SNA use article metadata (title, abstract, author organisations, keywords, and references, among others) to detect research trends and collaboration patterns (Khan et al., 2016). SNA, specifically, allows for the automatic identification of co-occurrences among variables and the visualisation of such information in the form of networks, giving meaning to a large number of scattered information in scientific publications. In addition to the visualisation of the information, SNA uses metrics – such as average degree, closeness and betweenness centrality (Kothari et al., 2014) – to assess the relationships between variables, thus helping to identify the most central nodes in the network and the most relevant links between them. To perform such tasks, both bibliometrics and SNA make intensive use of data/text mining and network analysis software. Although bibliometrics and SNA studies may analyse the content of publications, this is not their primary focus. This marks another difference between them and literature review studies, which are focused on content analysis (Ellegaard & Wallin, 2015).

In this context, this article aims to perform a bibliometric and descriptive analysis to map the scientific production on Science Education for people with disabilities. Thus, once the scenario is presented, a reflection on the production of this area is performed. The main journals, research areas, authors, research organisations and countries were identified, as well as collaboration networks and organisations. For this purpose, bibliometrics and network analysis and content analysis techniques were used to analyse scientific publication records on the subject, indexed at the Clarivate Analytics Web of Science Core Collection (WoS) database.

Inclusive education and science teaching – theoretical background

One of the main pillars of SE research is the defence of the importance of scientific knowledge for citizenship exercise (Birmingham & Barton, 2014; Rudolph & Horibe, 2016; Santos & Mortimer, 2000). Since the end of the 19th century, an ethical discussion on how individuals must master a basic knowledge of nature and its phenomena has been consolidated in order not only for these to become 'social beings' but also to carry out coherent decisions in society (Chassot, 2003; Roth & Lee, 2004). Thus, science knowledge would have an equivalent role in the training of a student as that of languages, arts, social sciences, physical education and mathematics, comprising scientific literacy (Brown et al., 2005; Chassot, 2003; Hand et al., 2010; Roth & Lee, 2004).

This premise subsidises, and is subsidised in reverse, to the idea of democratic and liberating education, in which individuals, as citizens, have the social right to access the body of knowledge generated by humanity to effectively exercise their social role (Borreda & Pena, 2016; M. G. Villanueva & Hand, 2011). Furthermore, imagining a modern democratic society, this right must be defended for all, in the greater sense of what citizenship is (Bassiano & De Lima, 2018; Freire, 1989; Vesterinen et al., 2016). Thus, the concepts of democracy, citizenship and scientific literacy intersect and have the recognition of difference and diversity (not their denial) in common, but the perception that such differences are not a reason for social exclusion or segregation (Scruggs et al., 2013).

This being said, IE for people with disabilities becomes an affirmative discourse. In this article, the term 'people with disabilities' is considered as those students who need additional support for learning and instruction (M. G. Villanueva & Hand, 2011; Villanueva et al., 2012). Therefore, this definition includes students who exhibit intellectual disabilities, learning difficulties (LD), talented, emotional or behavioural needs, physically dependent, deaf/blind, deaf or hearing impaired, visual and chronic health deficiencies, also referred to as exceptionalities (Hallahan et al., 2020; Villanueva et al., 2012). Indeed, several definitions are available, and the term, due to its polysemy, can be related to others such as 'students with special needs', 'exceptional students' and 'special students', among others. However, our intention in this article is not to discuss these various designations, and we understand that several cases reported in the literature use 'special needs' to cover all groups of people displaying some form of learning barrier. Because of this, we used several equivalent keywords to search for articles.

Disabled people have a civil right to education (Konur, 2000; Moore & Grossman, 2016), including science education, just like any other person. Furthermore, viewing education in an inclusive way, i.e., in the context of ordinary classes, brings another important general scenario, where young people who grow up in a different school context tend to better understand how diverse society is (Comaru, 2017; Probst, 2003; Silva Neto et al., 2018). Episodes frequently broadcast worldwide related to intolerance, violence and a lack of understanding of difference, are heinous examples of how some social groups do not know and have not learnt to live with the different. In this sense, the more diverse classrooms (all, including science ones) set up, as a reflection of society as it really is, the more we will contribute to the formation of more fraternal and supportive citizens (Bassiano & De Lima, 2018; Cawley et al., 2002; Freire, 1989; Sanahuja et al.; Vayrynen & Paksuniemi, 2020). Thus, the discussion on IE has a much more human and social character, bringing up concepts such as Inclusive Pedagogy in which the teacher is concerned about the individual characteristics of each student without marginalising some of them, taking into account differences and avoiding repeating exclusion (Florian & Beaton, 2018). In addition, the teacher who listens to his students and is concerned about carrying out practices that are effectively meaningful to them gives his action the true meaning of inclusion (Florian & Beaton, 2018; Kim et al.; Spratt & Florian, 2015).

Thus, research in SE for diversity seeks to subsidise teachers in their action-reflection that allows them to choose inclusive pedagogical paths (Novoa, 1992; Rock et al., 2016).

Methods

Bibliometrics and network analysis techniques were used to map scientific publications related to SE and IE indexed in the Clarivate Analytics' Web of Science Core Collection (WoS). The publications were gathered using the following search strategy:

> ts=(science* AND ("need special" OR "special needs" OR "special education" OR disabilit* OR "inclusive education"))
>
> Refined by: DOCUMENT TYPES: (ARTICLE OR REVIEW) AND RESEARCH AREAS: (EDUCATION EDUCATIONAL RESEARCH)
>
> Timespan: 2009-2019. Indexes: Science Citation Index Expanded (SCI-EXPANDED); Social Sciences Citation Index (SSCI); Arts & Humanities Citation Index (A&HCI); Conference Proceedings Citation Index- Science (CPCI-S); Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH); and Emerging Sources Citation Index (ESCI).

The search was performed on the WoS in July 2019 and a total of 594 publication records were obtained. Articles and review articles with keywords related to science and special needs or special education or disabilities or inclusive education in their titles or abstracts were included and classified into the subject area Education Educational Research. The search was set to include all Citation Indexes and retrieve articles published between 2009 and July 2019.

After reading the title, abstract and keywords of all publications, 119 were considered more specific to SE and IE and were, therefore, highlighted in the results. Although related, the other publications were considered more comprehensive, referring to subjects such as physical education teaching, mathematics only, languages, social sciences, educational technologies for teaching other non-natural science contents, disabled medicine and health, public policies and curriculum policies, indigenous and/or rural education, gender, racism and other social issues. It is understood that the concept of inclusive education encompasses all of the aforementioned groups, excluded from this study, although the decision to exclude them from the analysis allows us to focus only on studies on students with disabilities and thus, be able to better understand how the research community has been meeting the demands of this specific student group.

The 594 records were imported into the VantagePoint 11.0 software, where (a) duplicated records were removed (one record); (b) authors' names and affiliations and cited references were cleaned and standardised; and (c) co-occurrence matrices for authors and their affiliations, research areas and countries were built. These matrices were then imported into the Gephi 0.9.2 software, where networks were built using the Fruchterman Reingold layout algorithm.

Following the perspective of a mixed research (Mayring, 2014), the contents of the titles and abstracts of the 119 articles selected as samples were also analysed using the MaxQDA software. Guided by the research questions of understanding SE production on IE, the following units of analysis were determined for the content analysis (categories) (Bardin, 2011): (1) Specific fields of science/Knowledge area; (2) Central theme/objectives; (3) Education level, and; (4) Types of addressed disability.

Results and discussion

Figure 1 to 5 present the results of all 593 publications and the subset of 119 (20% of the total) publications more closely related to SE and IE. Figure 1 depicts the distribution of articles over time and the most frequent journals in which those articles were published. Overall, the number of publications increased over time (data for 2019 were collected in July of the same year, so they are still incomplete). It is observed that the production registered in 2009 (19 articles) more than quintupled in 10 years (105). An increasing production trend is also noted when verifying the specific group of selected productions, of five in 2009, increasing to 22 in 2018. These articles were published in over two hundred journals, the top three being *Remedial and Special education* (3.71% – 2018 Impact factor: 2.617), *Research in Developmental Disabilities* (3.20% – 2018 Impact factor: 1.872) and *Research and practice for persons with severe disabilities* (3.06% – 2018 Impact factor: 1.795). However, the distribution of the 119 selected articles among the most frequent journals did not follow the overall set. About 6% of them were published in *Education and Training in Autism and Developmental Disabilities* (2018 Impact Factor: 0.824) and 4.20% in *Learning Disabilities Research & Practice* (2018 Impact Factor: 2.077). Two of the most frequent journals (*Research in Developmental Disabilities* and *the International Journal of Inclusive Education*) did not publish any of the selected articles.

It is worth noting that articles that effectively deal with SE (those in the restricted group of 119), for the most part, are not published in SE magazines, but in magazines in the field of education for the disabled or special education. This indicates that there is still little entry for this type of discussion in the SE area, i.e. the discussion that combines SE and IE is found

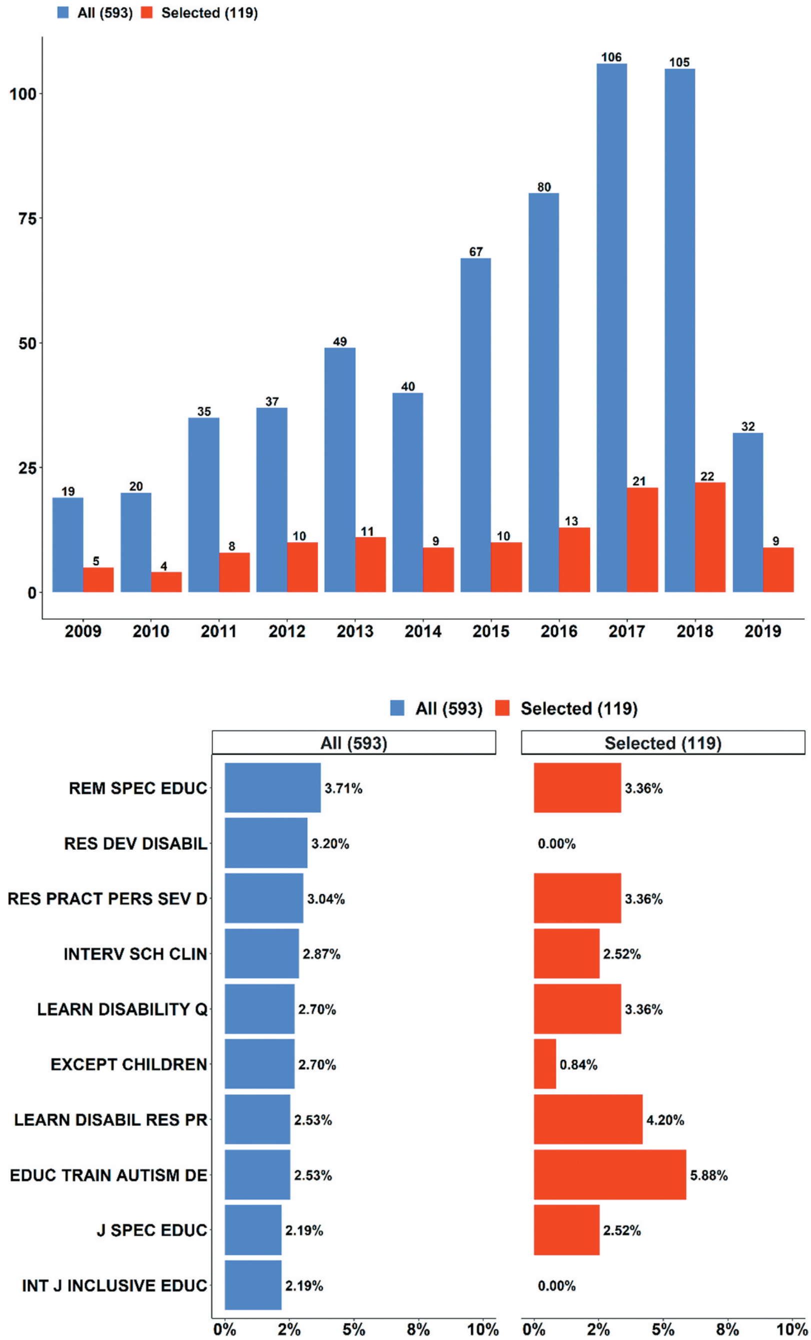

Figure 1. Publication year and leading journals.

in IE journals. These data corroborate the study carried out by Starcic & Bagon, which points out how difficult it is to access IE research results in the science area (Starcic & Bagon, 2014).

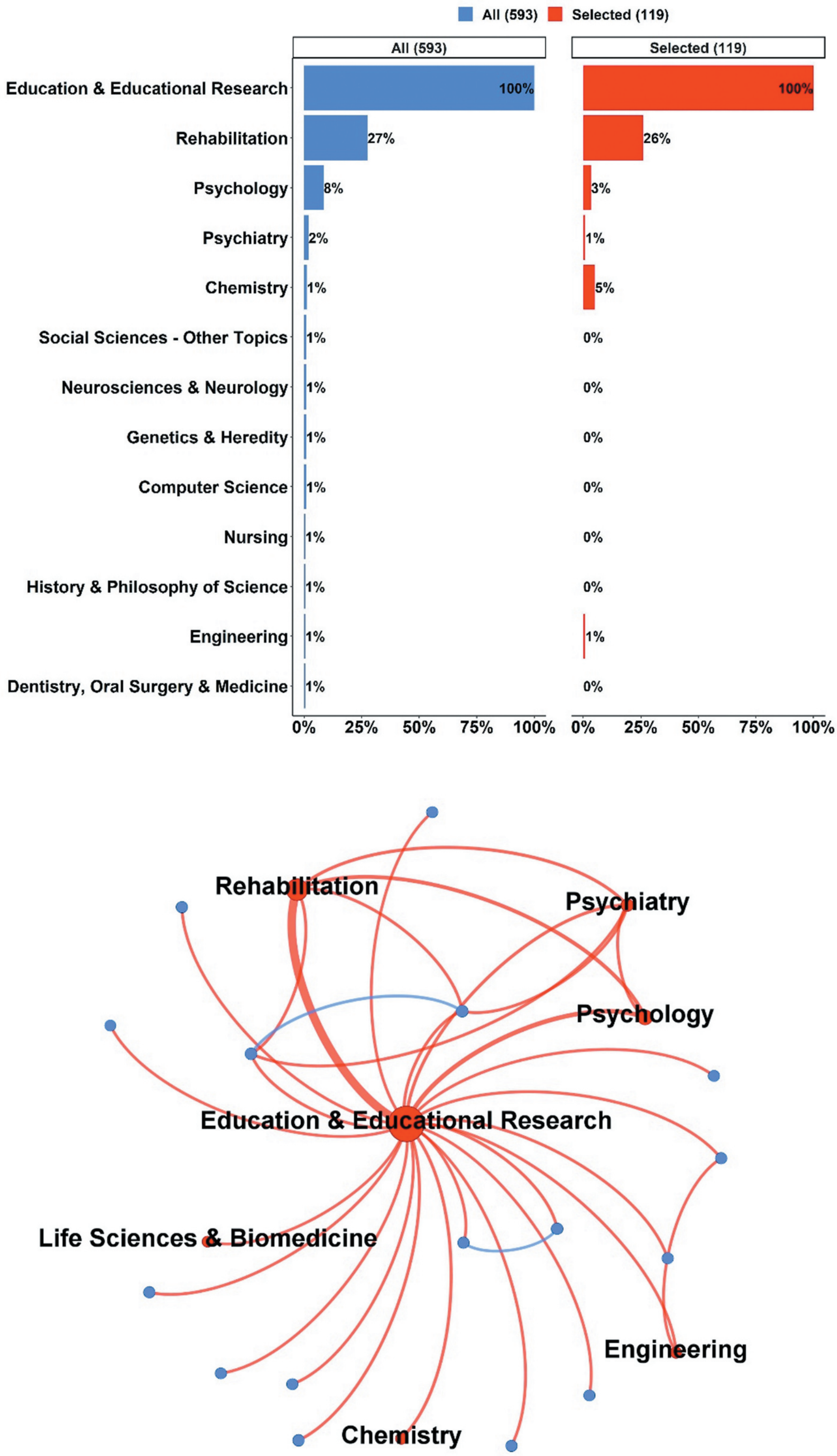

Figure 2. Research areas and their networks.

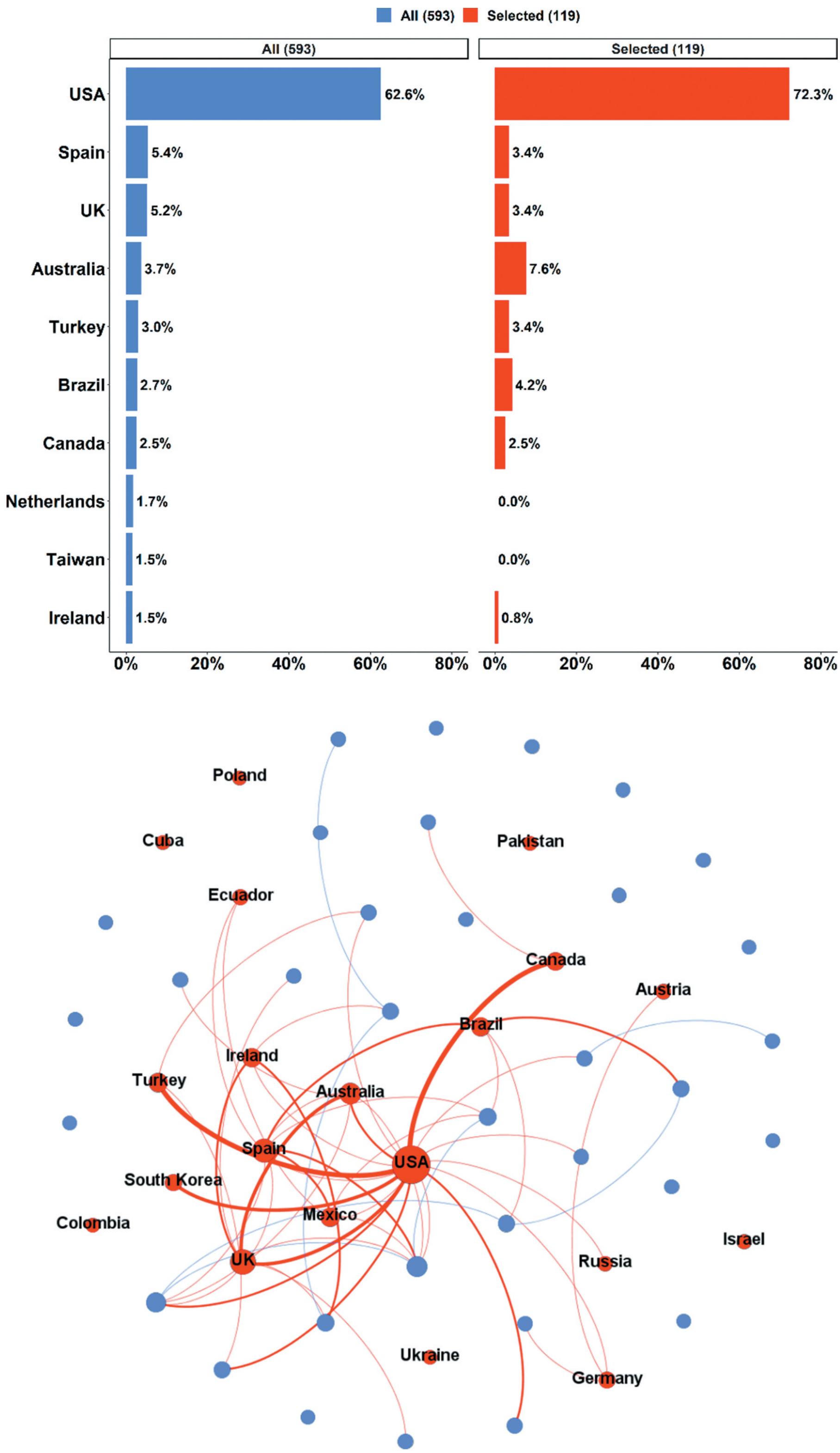

Figure 3. Countries and their networks.

The SE journal where the highest number of IE and SE articles was published in was *the Journal of research in science teaching* (2018 Impact Factor: 3.135) (five articles), followed by *Education Sciences* (no Impact Factor) (three articles).

Figure 2 displays the most frequent research areas assigned to the articles, following the WoS subject categorisation scheme (Clarivate Analytics: https://images.webofknowledge.com/images/help/WOS/hp_research_areas_easca.html), where articles can be assigned to more than one research area. The query that retrieved the 593 articles defined that all records should belong to the research area *Education & Educational Research. Rehabilitation* ranks second as the most frequent research area for both the group of all publications and the group of selected publications. *Psychology* and *Chemistry* ranks third for the former and the latter, respectively.

The networks displayed in Figures 2, 3 and 4 were built using all publication records (593), but we chose to emphasise the nodes of the selected articles. Therefore, red nodes and edges refer to the selected publications in the networks. Additionally, the weighted degree (sum of connected nodes weighted by the number of co-occurrence between nodes) was used to set the size of the nodes in all networks.

Concerning the network of research areas (Figure 2), the nodes represent the research areas and the edges, their co-occurrence. Only the nodes related to the selected articles were labelled. The research area *Education & Educational Research* is the most significant and most central node, where all publications are indexed in. After this central node, the research areas *Rehabilitation* and *Psychiatry* are the most central ones, with the same closeness and betweenness centrality value, although *Rehabilitation* has a higher weighted degree compared to *Psychiatry*. Betweenness centrality is related to the capacity of the node to reach other nodes through the shortest path, while closeness centrality measures the distance of the node from all other nodes. Their relevance in the network is also justified, as they are linked to other nodes besides *Education & Educational Research*.

Node centrality and the close correlation with the Rehabilitation and Psychiatry areas reveals that the discussion approach in articles that relate to SE and IE is still restricted to essentially medical-biological models. Thus, as Macdonald points out, only a small amount of research on education for people with disabilities attempts to locate studies also within a sociological context (Macdonald, 2009). Concerning the natural sciences, Chemistry is the only area that appears in an IE production context, with a total amount of seven records in the list of 119 selected (5%) dealing specifically with teaching chemistry, highlighting the role of this scientific area (De Bastos et al., 2016). Two records were published in 2016 in the *Journal of Chemical Education* (2018 Impact Factor: 1.763). These are abstracts invited to be presented at the 'Interactive Visualizations for Chemistry Teaching and Learning ACS CHED Committee on Computers in Chemical Education online ConfChem', held between 8 May and 4 June 2015. One brings a discussion on accessible educational technology resources, the use of screen readers to read chemical content, interactive simulations and experiences of students with disabilities and their teachers (Moore & Grossman, 2016). The other discusses ideas about combining 3D models with simulations and the possible benefits of using them for teaching chemistry (Moore, 2016).

Over 1,600 authors were identified in the 593 retrieved articles, belonging to about 500 different institutions from 54 countries. The selected articles (119) comprised about 300 authors affiliated to over 100 organisations from 20 different countries. This result points to a scientific production dispersion in the area regarding institution origins, although scientific production was concentrated on the United States of America (USA). The ranking of countries and the network of countries are presented in Figure 3. The networks displayed in Figures 3 and 4 are based on author affiliation information. The USA, as noted previously, is the main country, comprising over 62% of total publications and more than 72% of the selected articles. Among the group of selected articles, Australia appears in second place with 7.6%, and Brazil appears in third, with 4.2%, configuring these three countries as production nuclei. To ensure efficiency and science teacher support, it is essential that these countries' educational policymakers devote attention and resources to professional training (Spektor-Levy & Yifrach, 2019). It is also necessary to develop an applied research agenda in training special education teachers (Maheady, 2018). It is important to note that the advance of SE and IE research in these countries may be due to the implementation of these public policies.

The United States has a long tradition of special education research and practices in the form of inclusion (Mokter, 2012). Since passage of the Education for All Handicapped Children Act (EAHCA) of 1975, now referred to as the Individuals with Disabilities Education Act (IDEA) of 2004, free appropriate public education has been available to all children with disabilities. Based on a general public consultation held in 2008, the Australian government created the National Disability Strategy, a document developed by the Commonwealth in partnership with territorial governments, whose aim is to ensure that people with disabilities have an opportunity to fully participate in the economic and social spheres and the nation's cultural life and reflects the Australian government's commitment to social inclusion. Since then, this document has served as a public policy reference for the education of children, young people and adults with disabilities in Australia (Deane & National People with Disabilities and Carer Council, 2009, p. 1). Likewise, in Brazil, institutional policies and the law also advocate access and inclusion for children and young people with disabilities in basic public education. However, this is not an easy goal to be achieved, especially considering the context of material shortages that affect the vast majority of public schools in Brazil (Comarú et al., 2019). Even so, many efforts have been made to improve teaching methods and teacher training aimed at inclusive education (Comaru, 2017).

The country network includes all the retrieved records. Nodes represent the countries and the edges represent the collaborations between the authors of those countries. Only the red nodes are labelled, to highlight countries with publications among the group of selected publications. Nodes connected with thicker edges represent countries that collaborate more intensely. USA-Canada and USA-Turkey collaborations are the most important in the network. Some countries remain isolated concerning production, such as Poland, Pakistan, Colombia, Israel and Ukraine. This may be related to the fact that the productions often discuss the specific realities of each country or report on specific experiences (Can et al., 2017; Kang & Martin, 2018; Rivero et al., 2018; Tamayo et al., 2019)

The USA is the most central node, followed by the UK and Spain, the latter displaying the highest betweenness centrality in the network, indicating that they work as a bridge for other countries' collaboration efforts.

Figure 4 shows the most frequent organisations publishing research related to the subject of this paper. The organisations with the highest number of publications are all located in the USA. The University of North Carolina comprises almost 8% of total

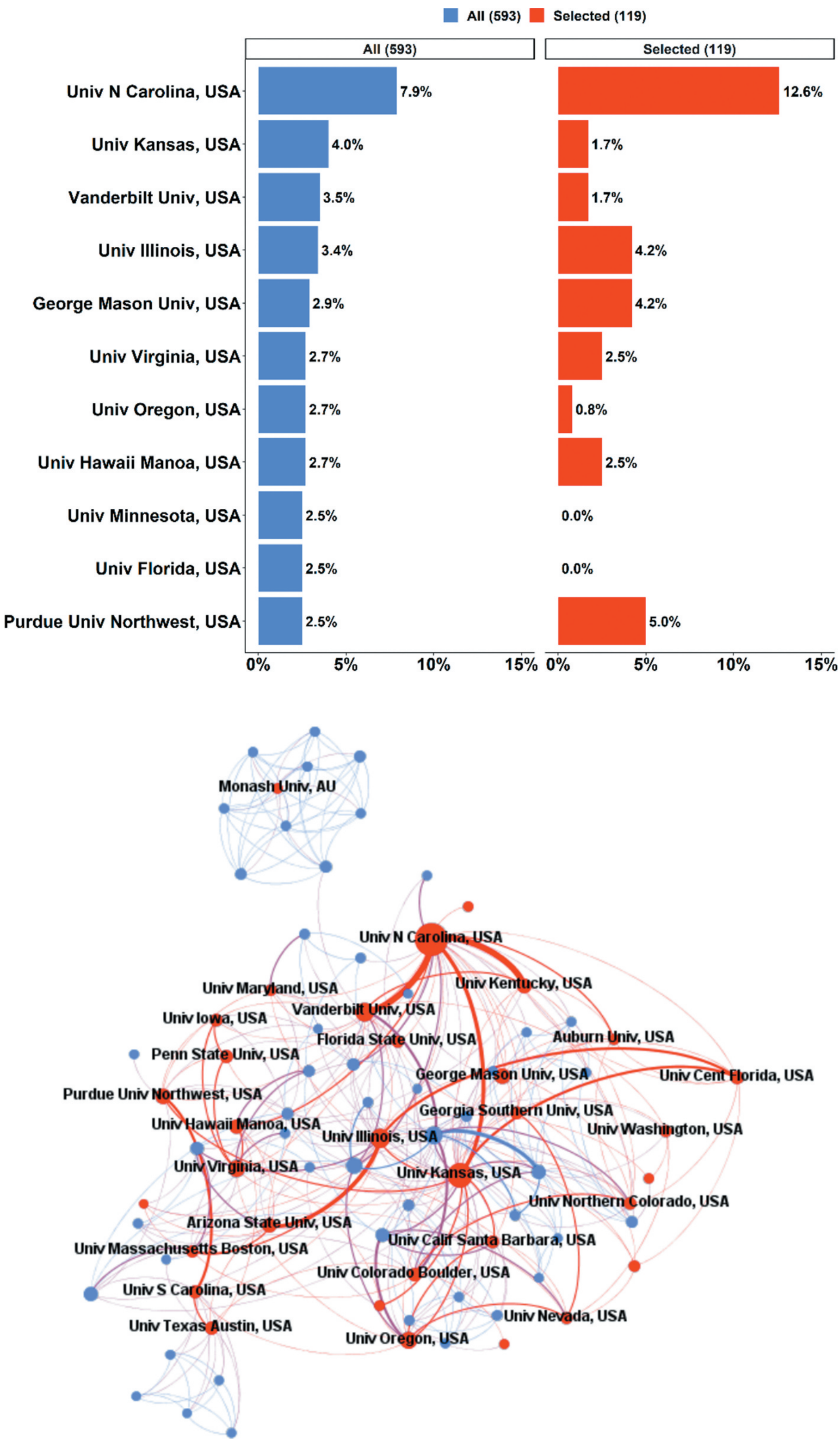

Figure 4. Main organisations and their networks.

publications and 12.6% of the selected articles. Authors from Purdue University Northwest authored 5% of the 119 selected articles, representing 2.5% of total records.

Only nodes with a weighted degree above the average (11.03) are displayed in Figure 4, to emphasise the most important organisations. The University of North Carolina is the largest node with the highest weighted degree but is not the most central node in the network. Three of the most productive authors in the field (Diane Browder, Fred Spooner and Belva Collins) as discussed ahead are attached to the *Department of Special Education and Child Development*. The Vanderbilt University presented the highest betweenness centrality, while the University of Kansas has the highest eigenvector centrality, indicating they both occupy the central position in the network. Eigenvector centrality is related to the capacity of the node to connect to other important nodes. Organiations with central positions are considered as those with more access to resources, such as funding, and strategic in maintaining and increasing collaboration between institutions (Tsai, 2001; Fonseca et al., 2017). Of the group of selected articles, the Australian Monash University is the only organisation with an above average degree located outside the USA, collaborating with other organisations that did not appear in the selected articles.

Figure 5 depicts the authors with the highest number of publications and the network of authors among the group of 119 selected publications. Fred Spooner published at least 16 articles, eight of them a part of the group of selected publications. These articles are about teaching science to students with severe disabilities and include teacher training, inquiry-based tasks, Systematic Instruction and Graphic Organisers. Considering the group of selected articles alone, Diane Browder is the most productive author. Her work is also related to teaching science or training teachers. Both researchers are associated with the *Department of Special Education and Child Development*, at the University of North Carolina.

The network of authors was built only with the 119 selected articles, used the modularity algorithm to detect and colour the communities. Modularity is a measure that indicates in which way the network could be divided into sub-networks. The modularity algorithm found 84 communities, but only those comprising over 2.45% of the nodes were labelled and coloured.

The red community consists of 7.34% of all nodes and includes both Diane Browder and Fred Spooner, the authors with the highest weighted degree inside the community and in the network, although the author with the highest betweenness centrality is Victoria Knight, followed by Fred Spooner, Belva Collins and Jimenez Bree. Authors displaying this central role in the network are expected to have not only access to strategic resources but to new information and to find and collaborate with authors disconnected from the network (Abbasi et al., 2011; Fonseca et al., 2017).

Another author with a significant per cent of selected articles is Willian Therrien (3.40%), who shares a central role in the blue community with Jonte Taylor. Although Thomas Scruggs and Margo Mastropieri have the same per cent of articles of Willian Therrien, they belong to a smaller community, comprising only 1.83% of nodes. Joseph Boyle did not collaborate with other authors in the selected articles, thus consisting of a solo community.

Table 1 shows the most cited references in the group of selected articles. The two most cited references are the 1996 *National science education standards* (15.9%) and the 2006

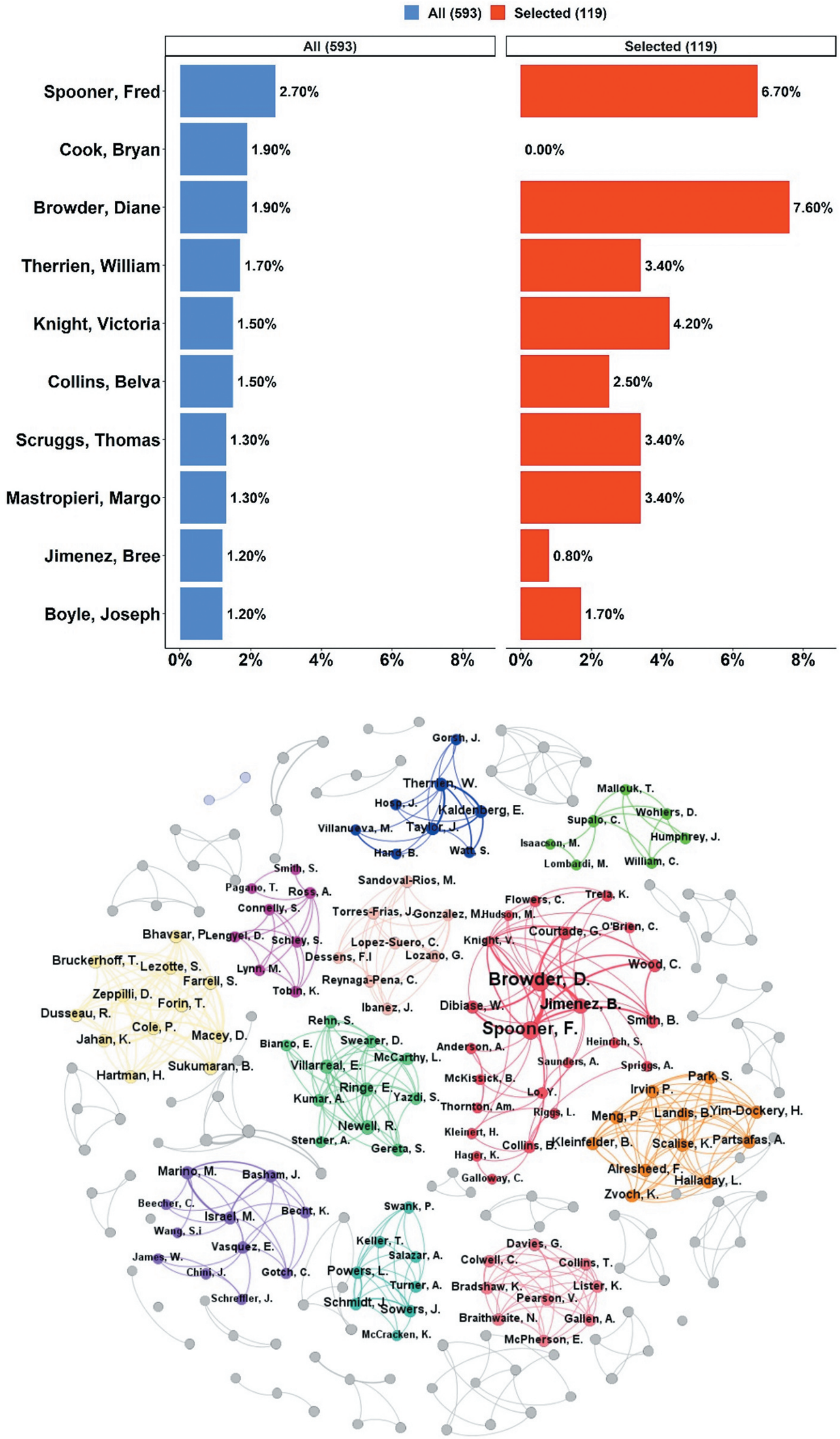

Figure 5. Main authors and their networks.

Table 1. Top 10 most cited references (selected articles (119)).

Title	Authors	Total of citations
1- National science education standards	(National Research Council, 1996)	19
2- Differentiated Curriculum Enhancement in Inclusive Middle School Science: Effects on Classroom and High-Stakes Tests	(Mastropieri et al., 2006)	15
3- Including students with disabilities into the general education science classroom	(Cawley et al., 2002)	14
4- Review of studies with students with significant cognitive disabilities which link to science standards	(Courtade, Spooner & Browder, 2007)	14
5- Reading versus doing: The relative effects of textbook-based and inquiry-oriented approaches to science learning in special education classrooms	(Scruggs et al, 1993)	14
6- Science education and students with learning disabilities.	(Brigham et al., 2011)	12
7- Single Subject Research Methodology in Behavioural Sciences	(Gast, 2010)	11
8- Evaluating Evidence-Based Practice in Teaching Science Content to Students with Severe Developmental Disabilities	(Spooner et al, 2011)	11
9- The Use of Single-Subject Research to Identify Evidence-Based Practice in Special Education	(Horner et al, 2005)	10
10- Inclusive Inquiry Science Using Peer-Mediated Embedded Instruction for Students with Moderate Intellectual Disability	(Jimenez et al, 2012)	10

Differentiated Curriculum Enhancement in Inclusive Middle School Science: Effects on Classroom and High-Stakes Tests (12.6%).

The *National Science Education Standards*, a book printed in the USA in 1996 by the National Academy of Sciences, presents the vision of a scientifically literate populace, outlining what students need to know, understand, and be able to do in order to be scientifically literate at different grade levels. They describe an educational system in which all students demonstrate high levels of performance, in which teachers are empowered to make the decisions essential for effective learning, in which interlocking communities of teachers and students are focused on learning science, and in which supportive educational programmes and systems nurture achievement. The Standards point towards a future that is challenging but attainable. This book was created with the aim of being adopted as a guide for scientific education practices and studies in the late 90s and 2000s. For this reason, it is the most frequent educational public policy reference.

The *Differentiated Curriculum Enhancement in Inclusive Middle School Science: Effects on Classroom and High-Stakes Tests* published in the Journal of Special Education by Mastropieri et al. (2006), is an investigation of differentiated practical activities (including experimental classes) versus traditional instructions directed by science teachers for students with disabilities. The article highlights the importance of peer mediation and the results indicate that practical collaborative activities statistically facilitate the learning of high school science content. In addition, the article is forceful in highlighting the importance of using complementary practical activities mediated by peers, which can provide the necessary review and practice for students with disabilities. It is a direct, blunt article that proves (both qualitatively and quantitatively) that science classes for people with disabilities are possible and necessary, and even points to inclusion as a path. For this reason, it has become a classic reference.

Assessing the presented data and going beyond the descriptive aspect, in order to provide a more analytical, conceptual and prospective review, we now move on to an overview of the topics covered by the group of the 119 selected articles. The predetermined categories (units of analysis) for the content analysis were: Level Education; Central Theme; Knowledge Area; and Types of Disability.

Discussing the educational level category, 74 papers pointed out which educational level was addressed in the study, while 45 did not mention this information in their titles or abstracts. The most cited education level was high school with 35 articles (47%) aimed at this schooling stage. This was followed by the elementary level, at 17 articles (20%), and the postsecondary level, at 11 (15%). In this sense, the vast majority of studies that investigate SE and IE do so in basic education and not in higher education. The significant number of studies in postsecondary school is noteworthy, which is directly related to the data on STEM area courses that follows.

When assessing the natural sciences areas dealt with in the articles, we observed that 68 documents pointed out specific areas, while the others dealt with general science topics, such as science curriculum, science vocabulary, scientific methodologies and instruments (like the use of graphics or scales) or scientific literacy. Table 2 exhibits the areas of knowledge covered in the articles and their frequencies.

Analysing article contents in the STEM area (Science, Technology, Engineering and Mathematics), it is clear that a series of support and incentive programmes for inclusion in postsecondary STEM courses is in place, especially in the USA, not only for people with disabilities but also for women and low-income populations, whose results are presented concentrated in a defined time interval. Some examples include the Alabama Alliance for Students with Disabilities in Science, Technology, Engineering, and Mathematics (AASD-STEM)(Dunn et al., 2018), the Pacific Alliance project (Takahashi et al., 2018) and the National Federation of the Blind Engineering Quotient (NFB EQ) from 2013 to 2016 in Baltimore, Maryland (I. Villanueva & Di Stefano, 2017).

Eighty-three documents referred to the type of disability targeted by the study, of which 24 (29%) addressed learning difficulties and 14 (17%), cognitive or intellectual disabilities. This is directly correlated to the journals in which these articles were published, as indicated in Figure 1. Concerning the other varieties of disabilities, visual disability appears as the most addressed, at 13 papers, followed by behavioural/autism, at 9, and deafness, at 8.

In order to further promote a reflection of this area on how literature and our studies have dealt with the intersection between these themes, we analytically observed the central contents/themes of the 119 selected articles using content analysis tools. The papers were categorised concerning discussions on (a) *Teaching methodologies and pedagogical activities* (42 articles = 35%), including examples on inquiry-based learning,

Table 2. The nine most cited knowledge areas (of 68 of the 119 selected articles).

Ranking	Knowledge area	Frequency	Documents %
1	STEM	22	32.35
2	Biology	11	16.18
2	Chemistry	11	16.18
3	Mathematics	5	7.35
3	Physics	5	7.35
3	Technology	5	7.35
4	Astronomy	2	2.94
4	Engineering	2	2.94
5	Arts	1	1.47

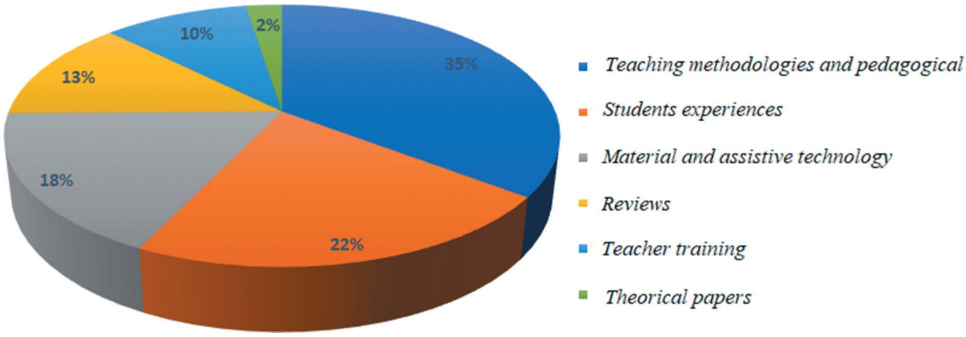

Figure 6. Central contents/themes of the 119 selected articles.

universal design, lesson study, olympics and student events, practically applied; (b) *Students experiences* (26 articles = 22%), including examples on investigations on students' perceptions and discourse; (c) *Material and assistive technology* (21 articles = 18%), such as video games, textbook, laboratory, reality augmented and robots, among others; (d) *Reviews* (15 articles = 13%); (e) *Teacher training* (12 articles = 10%); and (f) *Theoretical papers* (3 articles = 2%) concerning adapted curricula and access policies. The frequencies referring to each of these classes of themes are presented in Figure 6.

It is worth noting that very little is presented about the development of these educational technologies in articles that discuss methodologies and in those dealing with materials and resources. The vast majority discuss only the use, evaluation or performance of methodologies and resources already used in the traditional classroom in science teaching. Teachers remain attached to traditional practices, even in the face of the challenge of teaching students who learn differently (Camargo & Nardi, 2007).

Science teaching for SPD seems to be hampered, both by issues related to the experience or ability of teachers to make appropriate changes based on student needs and because of the instructions, methodologies and resources traditionally used in general education classrooms (Villanueva et al., 2012). Thus, a trend is noted in which studies attempt to adapt the methodologies and resources that teachers have already mastered to the reality of a class with SPD.

If we understand that, considering the inclusion concept defended by the area (Comaru, 2017; Probst, 2003; Silva Neto et al., 2018), practices, methods and resources must be thought, from their conception, as required to meet a diversity of students, then adaptations of something that already exists in an attempt to 'frame' what we already do cause a contradiction between theory and practice. In other words, we note herein that our research is not actually focused on inclusion, but rather on adaptation. A shift in focus is noted with the advent of the philosophy of school inclusion in the late 1990s, which was previously about SPD and which became for the programme and the school, giving rise to what can be understood as a quest to create schools that meet the needs of all students (Ferguson, 1996; Mendes, 2017), which is not noticeable in research carried out in the area of science education.

Inclusive education has been implemented in different degrees, with "blurred" and unclear boundaries (Hodkinson, 2011). Therefore, analyses on this topic must be carefully carried out, as it is the subject of power disputes.

Final remarks

Our results indicate an increasing number of articles relating to SE and IE. We agree with Cawley et al. (2002), the 3rd most cited reference, when they state that science classes are characterised by an extensive interpersonal contact between students and teachers and that this reveals the potential of science classes as being collaborative and supportive and, therefore, appropriate for IE (Cawley et al., 2002). Therefore, the growth in the number of research assessments presented herein suggests a tendency to recognise the importance of studies on the inclusion of students with disabilities in the science classroom.

However, a lack of recognition from the SE area, and from its main journals, concerning IE is noted. Journals that publish articles relating to SE and IE are mostly categorised as special education, rehabilitation and biomedical study areas. Thus, the discussion between researcher peers in SE is difficult. The results concerning collaborative networks were also very restricted. These analyses suggest that the state and study of change strategies are weak and that the research communities that study and promote change are largely isolated from each other (Henderson et al., 2011).

As a bibliometric and network analysis is proposed, our study revealed the incipient quantitative increase of SE and IE research. A scenario of the last 10 years in which the main journals that discuss the subject are categorised as within the area of special education (and not of SE) and in which the authors are concentrated on a few research centres, mostly in a single country, has a direct impact on school practice since the number of SPD in ordinary school science classrooms increases exponentially (Cawley et al., 2002; Comarú et al., 2014; Mastropieri et al., 2006). It will be necessary to expand this SE research panorama to account for the needs of both students and teachers in the next decade.

It is the researchers that we point out in this study that focus on the 'how' to scientifically literate students with disabilities, and this field of investigation, perhaps because it is so new and, at the same time, so necessary, must be identified so that new researchers feel challenged to explore it, increasing scientific knowledge in the area and ensuring a fair, ethical and egalitarian science education.

Conclusions

This study contributes to the general understanding of this research area, through a bibliometric analysis and literature mapping of the subject. However, the sample was selected exclusively through the WoS database, which represents a limitation that excludes, for example, studies produced and published locally in languages other than English in non-indexed journals. On the other hand, this study provides an interesting mapping for SE and IE study scenarios and allows for an overview of the distribution of scientific knowledge from publications worldwide. In addition, it reflects the research growth in the area, which may subsidise new investments, public policies and investigations of this nature.

We conclude that, despite the growing number of articles, scientific production associating SE and IE is still scarce, concentrated, and not shared with the scientific community through scientific education journals. Furthermore, most research is focused on the use of methodologies and resources and not effectively focused on inclusive processes.

Acknowledgments

This work was supported by the INOVA-Fiocruz and Coordination for the Improvement of Higher Education Personnel (CAPES).

The authors dedicate this paper to Prof. Dr Sidnei Quezada Meireles Leite recently died for his enormous contribution to the field of science education in Brazil and worldwide.

Disclosure statement

The Author(s) declare(s) that there is no conflict of interest.

Funding

This work was supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior; Inova-Fiocruz.

Notes on contributors

Michele Waltz Comarú is a professor at the Federal Institute of Rio de Janeiro, a pharmacist and licentiate of biology, MSc in Biochemistry and a PhD in Teaching of Biosciences and Health from the Oswaldo Cruz Institute (RJ-Brazil). Dedicates most of her research to the area of teaching sciences in an inclusive context. She is also chief editor of the scientific journal "Educação Profissional e Tecnológica em revista" (ISSN: 2594-4827)

Renato Matos Lopes is a professor and researcher at the Oswaldo Cruz Foundation, with experience in vocational education and sciences and health education.He is licentiate in biology from the State University of Rio de Janeiro,received his MSc in biochemistry from the Federal University of Viçosa and PhD in biochemistry from the State University of Rio de Janeiro. He has published several articles and books on topics related to problem-based learning.

Luiza Amara Maciel Braga is currently a PhD student at Fluminense Federal University and a researcher at the Center for Strategic Studies of the Oswaldo Cruz Foundation. She received her BSc in economics from the Federal University of Rio de Janeiro and her MSc in economics from Federal University of Viçosa. She has authored papers using technology foresight, scientometrics, and network analysis.

Fabio Batista Mota is an analyst at the Center for Strategic Studies of Oswaldo Cruz Foundation, where he leads a research group of foresight, scientometrics, and network analysis studies. He received his BSc and MSc in economics from Federal University of Bahia and his DSc in economics of innovation from the Federal University of Rio de Janeiro. He has published several articles and book chapters on topics related to science, technology and innovation in health.

Cecília Galvão currently works at the Institute of Education, University of Lisbon. Cecília does research in Curriculum Theory, Didactics and Science Education. Their most recent publication is 'Avaliação do Currículo das Ciências Físicas e Naturais: percursos e interpretações'.

ORCID

Michele Waltz Comarú http://orcid.org/0000-0002-3307-4255
Renato Matos Lopes http://orcid.org/0000-0002-0175-6673
Luiza Amara Maciel Braga http://orcid.org/0000-0002-1726-2643
Fabio Batista Mota http://orcid.org/0000-0003-2401-7336

Cecília Galvão http://orcid.org/0000-0002-0347-4872

References

Abbasi A., Altmann J., Hossain L. (2011) Identifying the effects of co-authorship networks on the performance of scholars: A correlation and regression analysis of performance measures and social network analysis measures. *Journal of Informetrics 5*(4) 594-607. https://doi.org/10.1016/j.joi.2011.05.007.

Akhter, S., Pauyo, T., & Khan, M. (2019). What is the difference between a systematic review and a meta-analysis? In Musahl, V., Karlsson, J., Hirschmann, M.T., Ayeni, O.R., Marx, R., Koh, J. L., Nakamura, N. (Eds.), *Basic Methods Handbook for Clinical Orthopaedic Research*, (pp. 331-342). Springer. https://doi.org/https://doi.org/10.1007/978-3-662-58254-1_37.

Akuma, F. V., & Callaghan, R. (2019). A systematic review characterizing and clarifying intrinsic teaching challenges linked to inquiry-based practical work [Review]. *Journal of Research in Science Teaching*, *56*(5), 619–648. https://doi.org/10.1002/tea.21516

Anderson, C. W., Santos, D. L., Bodbyl, S., E. X., Covitt, B. A., Edwards, K. D., Hancock, J. B., Lin, Q. Y., Thomas, C. M., Penuel, W. R., & Welch, M. M. (2018). Designing educational systems to support enactment of the next generation science standards [article]. *Journal of Research in Science Teaching*, *55*(7), 1026–1052. https://doi.org/10.1002/tea.21484

Apanasionok, M. M., Hastings, R. P., Grindle, C. F., Watkins, R. C., & Paris, A. (2019). Teaching science skills and knowledge to students with developmental disabilities: A systematic review [Review]. *Journal of Research in Science Teaching*, *56*(7), 847–880. https://doi.org/10.1002/tea.21531

Arici, F., Yildirim, P., Caliklar, S., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: Content and bibliometric mapping analysis [Article]. *Computers & Education*, *142*(23). Article Unsp 103647. https://doi.org/10.1016/j.compedu.2019.103647

Bardin, L. (2011). *Análide de Conteúdo*. Edições 70.

Bassiano, V., & De Lima, C. A. (2018). Emancipatory education in the perspective of Paulo Freire [Article]. *Revista De Pedagogia Universitaria Y Didactica Del Derecho*, *5*(2), 111–122. https://doi.org/10.5354/0719-5885.2017.51974

Birmingham, D., & Barton, A. C. (2014). Putting on a green carnival: Youth taking educated action on socioscientific issues [article]. *Journal of Research in Science Teaching*, *51*(3), 286–314. https://doi.org/10.1002/tea.21127

Borreda, L. M., & Pena, A. V. (2016). Green chemistry and sustainability in science education in secondary schools [article]. *Ensenanza De Las Ciencias*, *34*(2), 25–42. https://doi.org/10.5565/rev/ensciencias.1688

Brigham, F. J., Scruggs, T. E., & Mastropieri, M. A. (2011). Science education and students with learning disabilities [article]. *Learning Disabilities Research & Practice*, *26*(4), 223–232. https://doi.org/10.1111/j.1540-5826.2011.00343.x

Brown, B. A., Reveles, J. M., & Kelly, G. J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning [Article]. *Science Education*, *89*(5), 779–802. https://doi.org/10.1002/sce.20069

Camargo, E. P. D., & Nardi, R. (2007). Dificuldades e alternativas encontradas por licenciandos para o planejamento de atividades de ensino de óptica para alunos com deficiência visual. *Revista Brasileira De Ensino De Física*, *29*(1), 115–126. https://doi.org/10.1590/S1806-11172007000100018

Can, D., Pekbay, C., Hakverdi Can, M., Kaya, G., Avsar Tuncay, A., & Candan, S. (2017). Disability in elementary school textbooks [article]. *Pamukkale Universitesi Egitim Fakultesi Dergisi-Pamukkale University Journal of Education*, *41*, 75–89. https://doi.org/10.9779/puje725

Cawley, J., Hayden, S., Cade, E., & Baker-Kroczynski, S. (2002). Including students with disabilities into the general education science classroom. *Exceptional Children*, *68*(4), 423–435. https://doi.org/10.1177/001440290206800401

Chassot, A. (2003). Alfabetização científica: Uma possibilidade para a inclusão social [Scientific literacy: A possibility for social inclusion] [research-article]. *Revista Brasileira De Educação*, *0*(22), 89–100. https://doi.org/10.1590/S1413-24782003000100009

Comarú, M. W., Oliveira, R. S., Santana, T. F. P., & Coutinho, C. M. L. M. (2014). Inclusão no ensino superior no brasil: panorama geral e mapeamento de deficientes visuais em cursos da área biomédica no estado do espírito santo. *Revista Eletrônica Debates Em Educação Científica E Tecnológica*, *4*(1), 32–51. https://doi.org/10.36524/dect.v4i01.65

Comarú, M. W., Pierini, M. F., Lopes, R. M., & Coutinho, C. M. L. M. (2019). Uma introdução sobre o potencial da aprendizagem baseada em problemas para a promoção da educação inclusiva. *Revista Educação & Linguagem*, *6*(Jan–Abr), 1–13. https://www.fvj.br/revista/wp-content/uploads/2019/05/1_REdLi_20191.pdf

Comaru, M. W. (2017). A educação inclusiva na formação dos novos professores de ciências. In Edifes (Ed..), *Ensinando a ensinar ciências: Reflexões para docentes em formação* (pp. 133–145). Edifes https://edifes.ifes.edu.br/images/stories/livro_final_com_capa.pdf

De Bastos, A. R. B., Lindemann, R., & Reyes, V. (2016). Inclusive education and science education: A study about the area propositions [Article]. *Journal of Research in Special Educational Needs*, *16*, 426–429. https://doi.org/10.1111/1471-3802.12302

De Leo-Winkler, M. A., Wilson, G., Green, W., Chute, L., Henderson, E., & Mitchell, T. (2019). The vibrating universe: Astronomy for the deaf [article]. *Journal of Science Education and Technology*, *28*(3), 222–230. https://doi.org/10.1007/s10956-018-9761-1

De Sousa, B. J., Voos, I. C., Manenti, D. S., Conceicao, J., & Barbosa, M. L. P. (2018). Professional development of natural sciences teachers on assistive technology: Convergences and divergencies [article]. *Virtualidad Educacion Y Ciencia*, *9*(17), 73–93. https://revistas.unc.edu.ar/index.php/vesc/article/view/22993

Deane, K., & National People with Disabilities and Carer Council. (2009). Shut out: The experience of people with disabilities and their families in Australia. National Disability Strategy Consultation Report. Canberra: National People with Disabilities and Carer Council, Department of Families, Housing, Community Services and Indigenous Affairs. https://www.dss.gov.au/sites/default/files/documents/05_2012/nds_report.pdf

Dehdarirad, T., Villarroya, A., & Barrios, M. (2015). Research on women in science and higher education: A bibliometric analysis. *Scientometrics*, *103*(3), 795–812. https://doi.org/10.1007/s11192-015-1574-x

Dunn, C., Shannon, D., McCullough, B., Jenda, O., & Qazi, M. (2018). An innovative postsecondary education program for students with disabilities in stem (practice brief). *Journal of Postsecondary Education and Disability*, *31*(1), 91–101. https://files.eric.ed.gov/fulltext/EJ1182338.pdf

Ellegaard, O., Wallin, J. A. (2015) The bibliometric analysis of scholarly production: How great is the impact?. *Scientometrics 105*, 1809–1831. https://doi.org/10.1007/s11192-015-1645-z

Ferguson, D. L. (1996). Is it inclusion yet? Bursting the bubbles. In M. S. E. A. Berres (Ed.), *Creating tomorrow's schools today: Stories of inclusion, change, and renewal* (pp. 16–37). Teachers College Press.

Florian, L., & Beaton, M. (2018). Inclusive pedagogy in action: Getting it right for every child [Article]. *International Journal of Inclusive Education*, *22*(8), 870–884. https://doi.org/10.1080/13603116.2017.1412513

Fonseca B. P. F., Silva M. V. P., Araujo K. M., Sampaio R. B., Moraes M. O. (2017) Network analysis for science and technology management: Evidence from tuberculosis research in Fiocruz, Brazil. *PLoS ONE 12*(8): e0181870. https://doi.org/10.1371/journal.pone.0181870

Freire, P. (1989). *Educação como prática da liberdade* (19a ed. ed.). Paz e Terra.

Gurevitch, J., Koricheva, J., Nakagawa, S., & Stewart, G. (2018). Meta-analysis and the science of research synthesis [Review]. *Nature*, *555*(7695), 175–182. https://doi.org/10.1038/nature25753

Hallahan, D., Pullen, P., Kauffman, J., & Badar, J. (2020). *Exceptional Learners.* Oxford Research Encyclopedia of Education. https://doi.org/10.1093/acrefore/9780190264093.013.926

Hand, B., Yore, L. D., Jagger, S., & Prain, V. (2010). Connecting research in science literacy and classroom practice: A review of science teaching journals in Australia, the UK and the United

States, 1998-2008. *Studies in Science Education*, *46*(1), 45–68. https://doi.org/10.1080/03057260903562342

Hayashi, M. C. P. I. (2012). *Sociologia da ciência, Bibliometria e Cientometria: Contribuições para a análise da produção científica*. IV Seminário de Epistemologia e Teorias da Educação.

Henderson, C., Beach, A., & Finkelstein, N. (2011). Facilitating change in undergraduate STEM instructional practices: An analytic review of the literature [review]. *Journal of Research in Science Teaching*, *48*(8), 952–984. https://doi.org/10.1002/tea.20439

Hodkinson, A. L. (2011). Inclusion: A defining definition? *Power and Education*, *3*(2), 179–185. https://doi.org/10.2304/power.2011.3.2.179

Holzberger, D., Reinhold, S., Lüdtke, O., & Seidel, T. (2020). A meta-analysis on the relationship between school characteristics and student outcomes in science and maths – Evidence from large-scale studies. *Studies in Science Education*, *56*(1), 1–34. https://doi.org/10.1080/03057267.2020.1735758

Jan, S. K., & Vlachopoulos, P. (2019). Social network analysis: A framework for identifying communities in higher education online learning. *Technology, Knowledge and Learning*, *24*(4), 621–639. https://doi.org/10.1007/s10758-018-9375-y

Jitendra, A. K., Edwards, L. L., Choutka, C. M., & Treadway, P. S. (2002). A collaborative approach to planning in the content areas for students with learning disabilities: Accessing the general curriculum. *Learning Disabilities Research & Practice*, *17*(4), 252–267. https://doi.org/10.1111/0938-8982.t01-1-00023

Joyce, J., Harrison, J. R., & Gitomer, D. H. (2020). Modifications and accommodations: A preliminary investigation into changes in classroom artifact quality [Article]. *International Journal of Inclusive Education*, *24*(2), 181–201. https://doi.org/10.1080/13603116.2018.1453876

Kang, D. Y., & Martin, S. N. (2018). Improving learning opportunities for special education needs (SEN) students by engaging pre-service science teachers in an informal experiential learning course [Article]. *Asia Pacific Journal of Education*, *38*(3), 319–347. https://doi.org/10.1080/02188791.2018.1505599

Khan, A., Choudhury, N., Uddin, S., Hossain, L., and Baur, L. A. (2016) Longitudinal trends in global obesity research and collaboration: a review using bibliometric metadata. Obesity Reviews, 17: 377– 385. doi: 10.1111/obr.12372

Konur, O. (2000). Creating enforceable civil rights for disabled students in higher education: An institutional theory perspective [Article]. *Disability & Society*, *15*(7), 1041–1063. https://doi.org/10.1080/713662018

Kothari, A., Hamel, N., MacDonald, J.-A., Meyer, M., Cohen, B., & Bonnenfant, D. (2014). Exploring community collaborations: Social network analysis as a reflective tool for public health. *Systemic Practice and Action Research*, *27*(2), 123–137. https://doi.org/10.1007/s11213-012-9271-7

Lid, I. M. (2015). Vulnerability and disability: A citizenship perspective [Article]. *Disability & Society*, *30*(10), 1554–1567. https://doi.org/10.1080/09687599.2015.1113162

Lopes, R. M., De Faria, D., Fidalgo-Neto, A. A., & Mota, F. B. (2017). Facebook in educational research: A bibliometric analysis [Article]. *Scientometrics*, *111*(3), 1591–1621. https://doi.org/10.1007/s11192-017-2294-1

Macdonald, S. J. (2009). Windows of reflection: Conceptualizing dyslexia using the social model of disability [article]. *Dyslexia*, *15*(4), 347–362. https://doi.org/10.1002/dys.391

Maheady, L. (2018). Developing and sustaining a research agenda in special education teacher education [article]. *Teacher Education and Special Education*, *41*(1), 86–96. https://doi.org/10.1177/0888406417725798

Mastropieri, M. A., Scruggs, T. E., Norland, J. J., Berkeley, S., McDuffle, K., Tornquist, E. H., & Connors, N. (2006). Differentiated curriculum enhancement in inclusive middle school science: Effects on classroom and high-stakes tests [Article]. *Journal of Special Education*, *40*(3), 130–137. https://doi.org/10.1177/00224669060400030101

Mayring, P. (2014). Qualitative content analysis: Theoretical foundation, basic procedures and software solution. Klagenfurt: Gesis - Leibniz-Institit für Sozialwissenschaften https://www.ssoar.info/ssoar/handle/document/39517

Mendes, E. G. (2017). Sobre alunos “incluídos” ou “da inclusão”: Reflexões sobre o conceito de inclusão escolar. In S. L. Victor, A. B. Vieira, & I. M. D. Oliveira (Eds.), *Educação especial inclusiva: Conceituações, medicalização e políticas* (pp. 60–83). Brasil Multicultural.
Mokter, H. (2012). An overview of inclusive education in the. In U. States, E. A. Joan, F. Joy Pedego, & K. C. Judith (Eds.), *Communication Technology for Students in Special Education and Gifted Programs* (pp. 1–25). IGI Global. https://doi.org/10.4018/978-1-60960-878-1.ch001
Moore, E. B. (2016). ConfChem conference on interactive visualizations for chemistry teaching and learning: Accessibility for PhET interactive simulations-progress, challenges, and potential. *Journal of Chemical Education*, *93*(6), 1160–1161. https://doi.org/10.1021/acs.jchemed.5b00772
Moore, E. B., & Grossman, P. D. (2016). ConfChem conference on interactive visualizations for chemistry teaching and learning: The cutting edge-educational innovation, disability law, and civil rights. *Journal of Chemical Education*, *93*(6), 1154–1155. https://doi.org/10.1021/acs.jchemed.5b00777
Mutch-Jones, K., Puttick, G., & Minner, D. (2012). Lesson study for accessible science: Building expertise to improve practice in inclusive science classrooms [Article]. *Journal of Research in Science Teaching*, *49*(8), 1012–1034. https://doi.org/10.1002/tea.21034
Novoa, A. (1992). *Os professores e sua formação* (D. Quixote, Ed. ed.). Don Quixote.
Pati, D., & Lorusso, L. N. (2017). How to write a systematic review of the literature. *HERD: Health Environments Research & Design Journal*, *11*(1), 15–30. https://doi.org/10.1177/1937586717747384
Probst, T. M. (2003). Changing attitudes over time: Assessing the effectiveness of a workplace diversity course [Article]. *Teaching of Psychology*, *30*(3), 236–239. https://doi.org/10.1207/S15328023TOP3003_09
Rivero, V. D. G., Alvarez, O. R., & Morales, R. C. (2018). Strategies of teaching-learning of nature sciences and attention to the diversity [Article]. *Revista Conrado*, *14*(65), 16–22. https://conrado.ucf.edu.cu/index.php/conrado/article/view/811/842
Rock, M. L., Spooner, F., Nagro, S., Vasquez, E., Dunn, C., Leko, M., Luckner, J., Bausch, M., Donehower, C., & Jones, J. L. (2016). 21st century change drivers: Considerations for constructing transformative models of special education teacher development [article]. *Teacher Education and Special Education*, *39*(2), 98–120. https://doi.org/10.1177/0888406416640634
Roth, W. M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education*, *88*(2), 263–291. https://doi.org/10.1002/sce.10113
Rudolph, J. L., & Horibe, S. (2016). What do we mean by science education for civic engagement? [Article]. *Journal of Research in Science Teaching*, *53*(6), 805–820. https://doi.org/10.1002/tea.21303
Santos, W. L. P. D., & Mortimer, E. F. (2000). Uma análise de pressupostos teóricos da abordagem C-T-S (Ciência - Tecnologia - Sociedade) no contexto da educação brasileira. *Ensaio Pesquisa Em Educação Em Ciências (Belo Horizonte)*, *2*(2), 110–132. https://doi.org/10.1590/1983-21172000020202
Schreffler, J., Iii, E., Chini, J., & James, W. Universal design for learning in postsecondary STEM education for students with disabilities: A systematic literature review [Review]. (2019). *International Journal of Stem Education*, *6*(1), 10. Article Unsp 8. https://doi.org/10.1186/s40594-019-0161-8
Scruggs, T. E., Brigham, F. J., & Mastropieri, M. A. (2013). Common core science standards: Implications for students with learning disabilities [article]. *Learning Disabilities Research & Practice*, *28*(1), 49–57. https://doi.org/10.1111/ldrp.12002
Silva Neto, A. D. O., Ávila, É. G., Sales, T. R. R., Amorim, S. S., Nunes, A. K. F., & Santos, V. M. (2018). Educação inclusiva: Uma escola para todos. *Revista Educação Especial*, *31*(60), 81–92. https://doi.org/10.5902/1984686X24091
Spektor-Levy, O., & Yifrach, M. (2019). If science teachers are positively inclined toward inclusive education, why is it so difficult? [article]. *Research in Science Education*, *49*(3), 737–766. https://doi.org/10.1007/s11165-017-9636-0

Spratt, J., & Florian, L. (2015). Inclusive pedagogy: From learning to action. Supporting each individual in the context of 'everybody' [Article]. *Teaching and Teacher Education*, *49*, 89–96. https://doi.org/10.1016/j.tate.2015.03.006

Starcic, A. I., & Bagon, S. (2014). ICT-supported learning for inclusion of people with special needs: Review of seven educational technology journals, 1970-2011 [Review]. *British Journal of Educational Technology*, *45*(2), 202–230. https://doi.org/10.1111/bjet.12086

Takahashi, K., Uyehara, L., Park, H., Jin, R. K., & Stodden, R. (2018). Internship to improve postsecondary persistence for students with disabilities in the STEM pipeline (practice brief). *Journal of Postsecondary Education and Disability*, *31*(2), 179–185. https://files.eric.ed.gov/fulltext/EJ1192073.pdf

Tamayo, J. P. U., Manzano, L. E. S., Santa, N. A., & Salazar, E. A. Q. (2019). Astronomia ConTacto: A strategy for astronomy outreach for the visually impaired [Article]. *Revista Cientifica*, 262–270. https://revistas.udistrital.edu.co/index.php/revcie/article/view/14498/14610

Thompson, D. F., & Walker, C. K. (2015). A descriptive and historical review of bibliometrics with applications to medical sciences. *Pharmacotherapy*, *35*(6), 551–559. https://doi.org/10.1002/phar.1586

Tsai, W. (2001). Knowledge Transfer in Intraorganizational Networks: Effects of Network Position and Absorptive Capacity on Business Unit Innovation and Performance. *The Academy of Management Journal, 44*(5), 996-1004. https://doi.org/10.2307/3069443

Vayrynen, S., & Paksuniemi, M. (2020). Translating inclusive values into pedagogical actions [Article]. *International Journal of Inclusive Education*, *24*(2), 147–161. https://doi.org/10.1080/13603116.2018.1452989

Vesterinen, V. M., Tolppanen, S., & Aksela, M. (2016). Toward citizenship science education: What students do to make the world a better place? [Article]. *International Journal of Science Education*, *38*(1), 30–50. https://doi.org/10.1080/09500693.2015.1125035

Villanueva, I., & Di Stefano, M. (2017). Narrative inquiry on the teaching of STEM to blind high school students. *Educ. Sci*, *7*(4), 16. https://doi.org/10.3390/educsci7040089

Villanueva, M. G., & Hand, B. (2011). Science for all: Engaging students with special needs in and about science [article]. *Learning Disabilities Research & Practice*, *26*(4), 233–240. https://doi.org/10.1111/j.1540-5826.2011.00344.x

Villanueva, M. G., Taylor, J., Therrien, W., & Hand, B. (2012). Science education for students with special needs. *Studies in Science Education*, *48*(2), 187–215. https://doi.org/10.1080/14703297.2012.737117

Zagrai, A. N., Ostergren, W. J., Borden, L. T., & Zeman, S. (2017). Improving competitiveness of engineering students with disabilities through focused learning [Proceedings Paper]. *Proceedings of the Asme International Mechanical Engineering Congress and Exposition, 2016*, *5*, 8. Article V005t06a012. https://doi.org/10.1115/IMECE2016-67982

Zupic, I., & Čater, T. (2014). Bibliometric methods in management and organization. *Organizational Research Methods*, *18*(3), 429–472. https://doi.org/10.1177/1094428114562629