Knowledge Network and Special Education: a Systematic Literature Review[1]

Rede de Conhecimento e Educação Especial: uma Revisão Sistemática de Literatura

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ABSTRACT: In this paper, the objective was to identify the existing knowledge network in the *Revista Brasileira de Educação Especial* (Brazilian Journal of Special Education) through the description of the relational pattern and some network metrics. The study consisted of a review with peculiar characteristics to the systematic review: the knowledge network analysis through keywords and graph theory. The search for papers took place in the aforementioned journal, reaching publications from 1992 to 2017. Three hundred and one papers and six hundred and fifteen different keywords were found. It was concluded that the knowledge network presents low density and high clustering index and that the keywords with higher degree and intermediation centrality were Special Education, Inclusive Education and Inclusion.

KEYWORDS: Disability. Special Education. Knowledge network.

RESUMO: Neste artigo, objetivou-se identificar a rede de conhecimento existente na Revista Brasileira de Educação Especial por meio da descrição do padrão relacional e de algumas métricas de rede. O estudo consistiu em uma revisão com características peculiares à revisão sistemática: a análise de rede de conhecimento por meio das palavras-chave e a teoria dos grafos. A busca dos artigos ocorreu na referida revista, atingiu publicações de 1992 a 2017. Encontrou-se 391 artigos e 615 palavras-chave diferentes. Concluiu-se que a rede de conhecimento apresenta baixa densidade e alto índice de clusterização e que as palavras-chave com maior centralidade de grau e de intermediação foram Educação Especial, Educação Inclusiva e Inclusão.

PALAVRAS-CHAVE: Deficiências. Educação Especial. Rede de conhecimento.

1 Introduction

Review papers, as well as other categories of scientific papers, are a form of research that uses sources of bibliographic or electronic information to obtain research results from other authors, in order to theoretically support a given topic. Two categories of review papers

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are found in the literature: narrative reviews and systematic reviews. The latter is subdivided into four other methods: meta-analysis, systematic review, qualitative review and integrative review (Rother, 2007).

Recently, a new way of analyzing the literature has emerged that presents peculiar characteristics to a systematic review: the analysis of the knowledge network. The knowledge network analysis is within the field of scientometrics - a perspective of measuring science. This analysis is more concerned with measuring its own knowledge and its development than strictly the involved object of study itself, for this reason it is closer to a natural perspective of systematic review. However, this perspective is not exclusive to traditional systematic reviews, which analyzes a certain theme or object of study, since it works with other epistemology, methods and variables, being able to reveal new perspectives on literature that can be paired with traditional ones.

Scientific knowledge, which results from the collective efforts of many researchers in all regions and fields of science, can be conceived as a complex system of many associated concepts that adapt to the real world over time (Yi & Choi, 2012). Thus, the understanding of how scientific knowledge is structured can promote new advances in science.

The concept of knowledge network has been used in the literature to denote the active articulation of cooperation between scientists or institutions, explaining the flow of information exchanges, exchanges of ideas and knowledge. In this sense, the knowledge network is a derivation or subcategory of the concept of social networks in scientific practice. However, other measures of knowledge network have recently been used, such as those of keywords (KWs) of papers - the works of Choi, Yi e Lee (2011), Khan e Wood (2015), Yi e Choi (2012), Zhu e Guan (2013), Zhu, Wang, Hassan e Haddawy (2013) are examples.

It is noteworthy that two KWs are considered connected if they appear in a paper together. As long as KWs are carefully selected by an author to identify the distinctive research focus of a paper (Abrahamson, 1996), they will represent component concepts and ideas, the way in which they are associated with the novelty of the paper involved. The organization of KWs for a scientific field is, therefore, oriented and influenced by the thoughts and logic of its researchers, which represents the structure of scientific knowledge in a given field. In this sense, the KWs of scientific papers could be a good representative of the elements of knowledge, since the concepts in a scientific field are represented and communicated in the form of KWs (Lee, Su, & Chan, 2010).

KW analysis makes it possible to examine the patterns of structural interactions observed in the quote networks, making it possible to determine the fundamental mechanisms underlying the patterns observed in the networks from an evolutionary perspective of the network, which may allow the construction of an integrative theory about the organization of scientific knowledge. Lee, Su and Chan (2010) took a significant step in the initiative to build and visualize a network of KWs using 556 keywords from 181 researchers in papers related to technology. Their results revealed interesting findings for understanding the structure of knowledge, the most notable being that, unlike quote networks, KW networks are not small-world networks, but rather free-scale networks with a modular and hierarchical structure.

Kuhn (2005) states that the hierarchical structure seems to be at the heart of the organization of scientific knowledge, a sub-product of the evolutionary process of knowledge. This conception seems consistent with the traditional belief that groups of researchers with the notion of a coherent scientific and intellectual worldview paradigm and a shared set of questions and methodologies are fundamental parts of intellectual thinking (Kuhn, 2005).

One of the advantages of this type of structure is that, in complex systems, the hierarchy allows to deal with the complexity of a system that grows continuously, that is, an exponential increase in the number of interactions between the elements, since it minimizes the necessary interactions and helps the system to function effectively and efficiently, thus increasing its ability to evolve (Simon, 1962). New concepts and ideas are often the result of a recombination of existing concepts or ideas. In terms of network, the degree of popularity of KWs serves as an indicator of the importance of the research topics they represent. In a network perspective, a keyword is configured as a vertex located in a KW network, its popularity is measured by the network variable centrality of intermediation, a metric that assesses the importance of a keyword to establish "bridges" between KWs or clusters of KWs. For example, a keyword that falls between two distinct research themes (that is, closely related groups of KWs) will have a high intermediation centrality index, based on the analysis done through the Graph Theory (Yi & Choi, 2012).

These relationships between KWs embody the representation of a network of KWs, represented by graphs. From the visualization of the graph, it is possible to provide insights on the organization and evolution of knowledge. A good example of this perspective is the work of Huang (2009), who examined the frequency of KWs in obstructive sleep apnea studies. This analysis revealed a tendency towards specialization and a large number of KWs that were used only once. Combined with the variety of subject categories, this seems to indicate a lack of continuity in this area of research and/or a great disparity in the object of research.

In the area of inclusion and Special Education in Brazil, there are several systematic reviews available (Pacheco et al., 2016; Pereira, Silva, Faciola, Pontes, & Ramos, 2016; Silva, Gonçalves, & Alvarenga, 2012; Souza & Mendes, 2017). Silva, Gonçalves and Alvarenga (2012) analyzed the inclusion of people with disabilities in regular Brazilian education, taking into account legal and social aspects. The bibliographic research was conducted in the databases of Latin American and Caribbean Literature in Health Sciences (LILACS), Scientific Electronic Library Online (SciELO), Cochrane Portal and Database of journal papers from the Faculty's Library and Documentation Service of Law at the University of São Paulo - USP (IUSDATA), considering all papers published up until December 2010.

More recently, Souza and Mendes (2017) described and analyzed what has been produced by the collaborative action-research developed in the area of Special Education in the perspective of school inclusion, in the period from 2008 to 2015, taking as a source the summaries of national theses and dissertations. Pereira et al. (2016) analyzed the scientific production about the inclusion of students with disabilities in Higher Education. The methodology adopted was a systematic review of the literature in the database of the Journals of the Coordination for the Improvement of Higher Education Personnel (CAPES), between the period 2003 and 2013. Regarding the social inclusion of people with disabilities, Pacheco et al. (2016) carried out a systematic review in order to understand the state of the art on the theme of health and mental and social inclusion through culture and art from 2005 to 2015. Abstracts from national and international scientific journals were selected, indexed in the Bireme databases.

However, these reviews are not a knowledge network approach to the area, in order to have a structure of knowledge in a specific area. Thus, a broad view of research, interests, subareas and themes has been developed, especially within the Brazilian academic environment. One way to approach this perspective would be from a total network, in other words, to take a scientific journal in the area as a reference in order to extract the network of knowledge that surrounds it. The *Revista Brasileira de Educação Especial* – RBEE (Brazilian Journal of Special Education) would be an excellent reference for setting up such a network, since it has been well established on a regular basis for over 20 years and is considered one of the publication references in the area, in Brazil. Thus, the objective of this paper was to identify the knowledge network developed in the *RBEE* through the description of the presented structural relational pattern along with some network metrics.

2 Method

The seven stages proposed by the Cochrane Collaboration were used, recognized worldwide for its methodological rigor in the planning and execution of a systematic review: Formulation of the question/problem; Location and selection of studies in databases; Critical evaluation of studies; Data collection in papers; Analysis and presentation of data; Interpretation of data; and Improvement and updating of the review (Bento, 2014; Galvão & Pereira, 2014), as well as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria. For the analysis of the selected papers, an instrument was developed based on the domains of population, exposure/intervention, comparator and outcome (PICO) (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009).

2.1 Database surveyed

The journal selected for the systematic review was the *RBEE* maintained by the Brazilian Association of Researchers in Special Education (*Associação Brasileira de Pesquisadores em Educação Especial* - ABPEE). A national journal that disseminates knowledge and the interchange among researchers in the field of Special Education and related areas, through publications of research papers, review papers, essays and book reviews. It was founded in 1992 and, until the end of 2017, had 23 volumes with a quarterly publication (ABPEE, 2018).

The choice of the journal is justified for the following reasons: it is a reference in the area of research in Special Education and inclusion in Brazil; it is classified in relation to Qualis issued by the Capes as A2 in the area of education and A1 in the area of Teaching and has been incorporated into the Scientific Electronic Library Online (SciELO), where the most recent editions of the journal are available. The access took place on two websites: *ABPEE* official website, which provides journals from 1992 to 2006, and SciELO website, from 2005 until today. The studies included in the research had to: (1) be published in the *RBEE*; (2) contain the keywords and have a summary - for this criterion, data were collected from 1999 to 2017, as only from 1999 onwards the keywords were systematically included in the papers; and (3) have an empirical research design. In refining the search, the following were excluded: (1) papers published in the *RBEE* since January/2018 and (2) type of paper with essay design, literature and bibliographic review, book review and experience report.

2.2 Procedure

In this subsection, we discuss how data collection took place; then, on the definition of search terms and keyword treatment; and, finally, on the instruments used in data analysis.

2.2.1 Data collection

In total, 45 editions of publications in the journal from 1992 to 2017 were analyzed. The papers included in the survey were organized in a spreadsheet in Excel 2013 containing the following descriptions: authors, year, volume and keywords. Considering the criteria stipulated above, 391 papers and 615 different keywords were found.

The data were extracted independently by two reviewers and organized in a predefined data extraction table. When there was a disagreement between the reviewers, they would resolve or consult a third reviewer.

2.2.2 Definition of search terms and treatment of keywords

After collecting the KWs from each paper, the "Standardization Chart" was created, in which similar KWs were standardized in a single term in order to approximate words with the same semantic value. Standardized KWs were developed based on some criteria: use of more current terms, in plural; use of acronyms; translation into Portuguese. After standardization, a combination was made between each keyword belonging to each paper. The KWs were arranged in a contingency table so that they would refer to vertices belonging to each paper.

2.2.3 Data analysis

For data analysis, the NodeXL version 1.0.1.251 tool was used, a template, which serves as an open-source add-in for Excel (2007, 2010 and 2013). Through NodeXL, it is possible to calculate metrics in order to identify dynamic interactions, scores of centralities of degree and intermediation between the elements that compose the set of variables of interest to the researcher, as well as generate graphical representations, in the form of diagrams and resulting graphs of the investigated relationships (Hansen, Shneiderman, & Smith, 2010).

3 Results and discussion

To present and discuss the results, this section is divided into three parts: Density, clustering and other metrics; Concept communities; KW analysis.

3.1 Density, clustering and other metrics

In Table 1 below, it is possible to identify the structural characteristics of the KW network. The 615 KWs found, after the standardization process, were reduced to 527. 2,374 combinations of KW pairs (referred to as adjacent KWs) were identified, 899 of which were duplicated, with an average of 3.94 KWs per paper. The network density index is low, since it has a value equal to 0.012 and the density result varies from a range between 0 and 1, indicating how the vertices are interconnected in the network. The density of the graph is calculated by dividing the number of total connections by the maximum number of possible connections, the more connections existing, the denser the network (Hanneman & Riddle, 2005).

The low density of the network, verified in the value of 0.012 (Table 1) and pointed out in the graph (Figure 1), indicates that there is a smaller number of vertices connected to all the others and a diversity of different clusters. Thus, the less dense network has a high rate of clustering. The score reached was high (0.84), which shows that the network is not connected at a global level, but has a high number of clusters, in which internally its elements (KWs) are densely connected, which is expressed in the topology of Figure 1. By observing these two data (density and clustering) in a complementary way, the low density of the KW network can be considered positive, as it reveals a diversity of variables being investigated in national surveys regarding the Special Education area; and the high index of clustering indicates this diversity, pointing to the fact that the number of researchers developing unprecedented and innovative research in this area is growing, showing how dynamic this subarea is. This aspect also indicates that the Special Education area is formed by subareas that are able to develop more intense communication, clusters in which the transit of knowledge in the network is intercommunicated in a better way.

Measure	Total
Papers	391
Average of KWs per item	3,94
Total standardized KWs (vertices)	527
Combinations between single KWs (single edges)	1475
Combinations between duplicated KWs (duplicated edges)	899
Combinations between KWs (edges)	2374
Connected components	7
Maximum number of KWs (vertices) connected in a component	507
Maximum connections (edges) on a connected component	2348
Maximum geodesic distance (diameter)	5
Average geodesic distances	2,286
Graph density	0,012
Modularity	0,327
Average clustering coefficient	0,84

Table 1. General structural characteristics of the Keyword network (KWs).
Source: Elaborated by the authors.

In the network graph shown below (Figure 1), resulting from the association between the KWs, it is possible to verify the existence of seven components. A component of a network is the isolated subnet in which the nodes are connected to each other, but are not connected to any other subnet within the total network (Hanneman & Riddle, 2005). In other words, within a component, all nodes are accessible to each other, but are disconnected from the other components of the network (Wasserman & Faust, 1994); therefore, it appears that the knowledge network present in the *RBEE* is composed of seven groups of knowledge that do not trace any type of relationship. The number of components informs about the intercommunication of concepts within a given field or, conversely, the existence of theoretical, conceptual and/or methodological barriers. Subsequently, the fields or communities of knowledge involved in these components will be discussed.

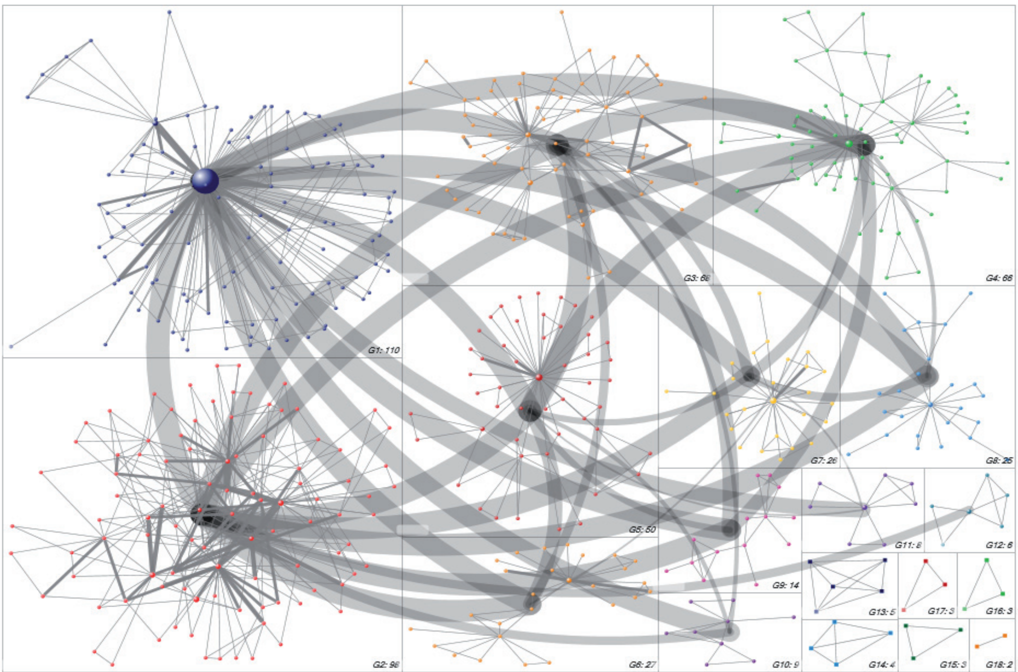

Figure 1. Communities of subgraphs produced from the RBEE network.

The diameter, represented by the maximum geodesic distance, presents the linear size of the network and provides the notion of the distance between the information or ideas that circulate in it. The maximum distance between two KWs in the network had a value of 5. The network obtained in the research has a small world pattern, that is, it has a high coefficient of clustering and a small average distance. The heuristic for determining a small world network according to Watts and Strogatz (1998) is that the average Clustering Coefficient (CC_{ij}) is greater than the density of the graph (CC_{rg}). In this network, $CC_{ij} = 0.84 > CC_{rg} = 0.012$ were obtained. The network also fulfills the small world requirement since, in the network of size N (number of keywords) with an average path length of L, it fulfills the distance requirement for a small world network if $L < 1 + log_{100} N$ (Yi & Choi, 2012). In this case, "L" fulfills the requirement of a small world: 2.28 <2.36. This also implies a high probability that two words linked to one another are, themselves, linked together.

In another sense, the structuring of the knowledge network present in the *RBEE* has a profile of free scale (Barabási & Albert, 1999). Figure 2 below shows the dispersion graph of the degree centrality (G) of the vertices, that is, the number of connections that one KW has with the others. The linear relationship presented here implies that the KWs follow a degree distribution of the power law in which the probability that a keyword has x connections is proportional to x - α (Barabási & Albert, 1999). This data is congruent to the work of Yi and Choi (2012) for the information technology area, in which, in such networks, most KWs have a small number of connections, but certain KWs are associated with a large number of KWs.

The curve formed in Figure 2 is different from a Gaussian curve; thus, the association between KWs does not appear to be random, but rather characteristic of a preferred connection. Networks with this profile have vertices with degrees of connectivity based on a power law in which most vertices have low connectivity (Barabási & Albert, 1999). In systems of this type, the vertex connectivity distribution tends to follow a preferential connectivity principle, since the greater the number of connections of a KW, the greater the probability that other KWs will preferentially connect to it. This pattern has been evidenced in biological, neural, linguistic and internet networks and tends to form more robust networks (Albert & Barabási, 2002; Barabási & Bonabeau, 2003; Barabási, 2009). We will return to this question later, presenting the characteristics of KWs in terms of networks.

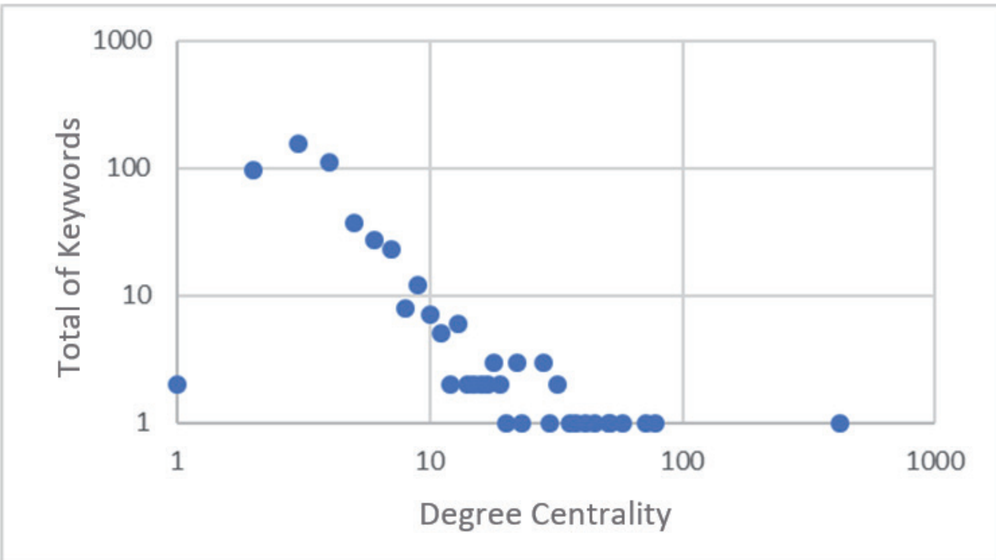

Figure 2. Degree of distribution of KW networks present in the main component of the RBEE network.

Being a network with a free scale profile, does it also have a hierarchical pattern or not? Many complex systems have an almost decomposable hierarchical structure (modular architecture) - the architecture in modules allows for understanding of the systems and their parts (Simon, 1962). In order to identify the presence of hierarchy, it is necessary to consider the correlation between the *G* of each keyword and its local grouping coefficient, which demonstrates a measure of the degree of the hierarchical structure. Figure 3 below shows the correlation between the degree of each keyword and the clustering coefficient on a base 100 logarithmic scale. On the one hand, in hierarchical networks, the correlation between the local clustering coefficient (connection density at a given vertex) and degree (the number of connections) exhibits scale behavior; on the other hand, in non-hierarchical networks (such as an electrical network), they usually exhibit constant grouping (Ravasz & Barabási, 2003; Ravasz, Somera, Mongru, Oltvai & Barabási, 2002). The results found in the *RBEE* network show a linear correlation, that is, it demonstrates that KW networks have a hierarchical structure (Ravasz et al., 2002).

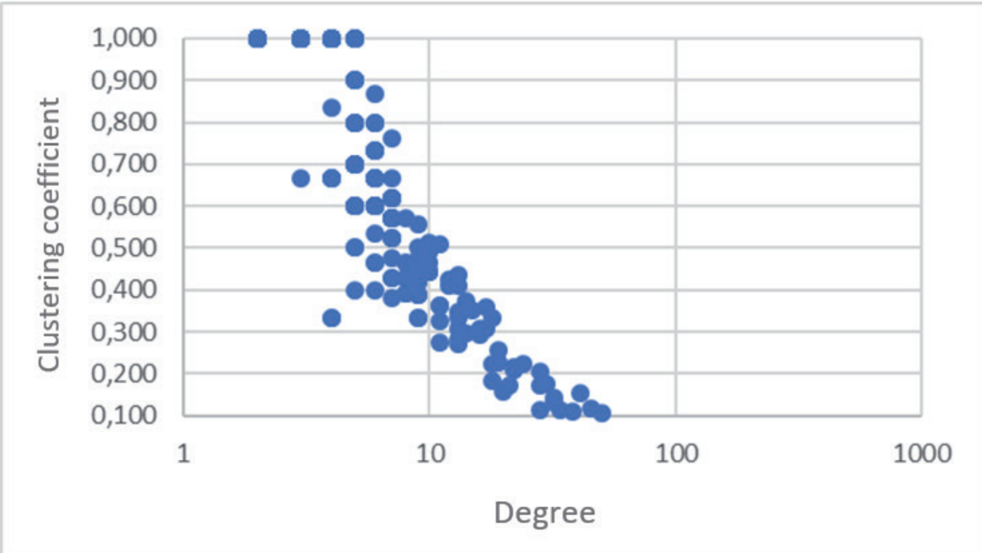

Figure 3. Correlation between the clustering coefficient and Degree centrality.

As conceived by Yi and Choi (2012), this structural characteristic provides clues about the generative mechanism underlying the organization and evolution of scientific knowledge. First of all, small groups of concepts are organized hierarchically in increasingly larger groups, which results in two fundamental characteristics of the network: a high degree of grouping and a topology without scale, as proposed by Ravasz and Barabási (2003). The modular structure found is indicative of sub-specialties that can be decomposed, but as they participate in the same cluster, they can be integrated into a more complex network.

3.2 Communities of concepts

Due to the characteristic of the network with a free scale standard, there are obviously KWs more connected to each other than to other KWs, thus constituting clusters with greater internal than external connections, which in Social Network Analysis (SNA) is called communities, here, analogously, these are communities of concepts. A community is understood as a group of vertices that have common properties, and/or perform a similar function within a network (Justel, Maia, Nobre, & Oliveira, 2014). The mathematical formulation for determining communities in a network is called graph clustering. In complex networks, communities, also called modules or clusters, are groups of vertices that probably share common properties and/or follow similar rules within the network (Fortunato, 2010).

The problem of community detection lies in the better division of the network into partitions of the set of densely connected vertices. The algorithm used here was a "greedy" algorithm, as it has an agglomerative profile, unites nodes/communities recursively. The CNM algorithm (Clauset, Newman, & Moore, 2004) seeks to partition the graph in communities in such a way that modularity is maximized. Modularity is a property of a network and a proposal to divide that network into communities, it measures when the division is good, in the sense that there are many edges within the communities and only a few between them.

Figure 1 presented above represents the clusters generated by the CNM algorithm in the *RBEE* network. The resulting clusters of the algorithm are in different quadrants and colors, the vertices of the clusters belonging to the same (main) component are presented in a sphere shape and the rest in a square shape. The total number of vertices in each cluster is represented in the lower right corner of each quadrant. The thickness of the edges indicates the frequency that pairs of KWs are repeatedly encountered. The connection between the clusters is represented by the gray lines and the greater the thickness of the line, the greater the frequency of connection between them. The sizes of the vertices are related to the value of their centrality of intermediation (CI), which reveals how much a vertex is in the path of others, representing the importance of KW in establishing bridges between other subsets of KWs.

It is noteworthy that, in a network perspective, a KW is configured as a vertex and its popularity is measured by the network variable centrality of intermediation, a metric that assesses the importance of a KW to establish "bridges" between KWs or clusters of KWs. For example, a KW that is between two different research topics (that is, groups of closely related KWs) will have a high intermediation centrality index, based on the analysis made through the Graph Theory. As can be seen in Figure 1, 18 clusters were found. It should be noted that part of these clusters make up the seven components found in the network, so that, of the 18 clusters, 12 form a single component (because there is a connection between these clusters, represented by the gray outline in the graph) and the other 6 form subgroups without any type of communication (edges) with the others (positioned close to the lower right corner). It appears that this large component covers a total of 95% of the network's KWs. Clusters reveal the communities of concepts within a network of keywords, the presence of clusters in that network expresses evidence of a close relationship between the keywords of the various research published in the journal, evidence of a theoretically pertinent articulation.

3.3 KW analysis

In the previous sections, global structural aspects of the network were discussed. In this section, properties at the vertex level (keywords) are discussed. Table 2 below describes the degree centrality (number of links that a keyword has with other KWs in the network) and the centrality of intermediation of the 21 highest KW values found.

Position	Measures					
	Degree Centrality (DC)	C	V	Intermediation Centrality (IC)	C	V
1st	Special education	1	423	Special education	1	108.690
2nd	Inclusive education	5	78	Inclusion	4	5756
3rd	Inclusion	4	72	Inclusive education	5	4822
4th	Cerebral palsy	2	58	Mental disability	7	3556
5th	Deafness	2	52	Regular education	2	3103
6th	Vision disorders	3	51	Down syndrome	2	2687
7th	Down syndrome	2	45	Students with disabilities	1	2413
8th	Families	2	41	People with disabilities	2	2374
9th	Intellectual disability	3	38	Deafness	2	2069
10th	Mental disability	7	36	Special needs	3	2018
11th	People with disabilities	2	32	Vision disorders	3	1919
12th	ASD	2	32	Gifted students	6	1600
13th	Evaluation	2	30	Hearing impairments	8	1580
14th	Hearing impairment	8	28	Scientific production	11	1537
15th	School inclusion	2	28	Cerebral palsy	2	1345
16th	Language	2	28	Families	2	1177
17th	Teachers	5	23	Elementary School	5	1016
18th	Gifted students	6	22	Visually impaired children	3	1008
19th	Physical education	2	22	Special classes	4	1008
20th	Physical disabilities	2	22	Curriculum	4	1008
21st	Students with disabi-lities	1	20	Work	12	1008

Table 2. 21 main keywords by vertex metric.
Legend: C = Cluster that participates; V = Value in the metric.

As can be seen, the keyword Special Education is the main hub in the investigated knowledge network, as it has the highest IC score. It is understood that intermediation represents a more precise measure in terms of the power of a KW in a knowledge network. Considering the values of the 21 largest IC, it appears that the main disabilities that mediate the knowledge network are: mental disability, Down Syndrome, deafness, hearing impairment, vision disorder and cerebral palsy. Aside from the disabilities, categories of KWs that move around teaching and education are highlighted: special education, inclusive education, regular education, gifted students, students with disabilities, elementary school, special classes and curriculum; and of concepts, fundamental rights and contexts involved: inclusion, people with disabilities, special needs, work and families.

With regard to the fields or communities of knowledge identified in the 12 main clusters, from the different papers that were part of this review (Figure 1 and Table 2), it was found that the cluster with the largest number of KWs is 1, but the keyword Special Education centralizes this field of knowledge, which makes most peripheral vertices of little importance in terms of intermediation - there is a much greater asymmetry here when compared to other clusters. Centralized profile networks tend to have a high degree of dependence on the intermediary vertex, since it controls the flow of intermediation in the network. In another sense, Cluster 2 has a smaller number of KWs, however it has a higher density, better distribution of IC, it has in its list six of the KWs with a higher IC and, comparatively, has a higher frequency of KWs with ICs above 0.001. Such networks with a more distributed profile tend to be more resistant due to the diversity of existing integration paths, as they are more distributed, have greater transitivity and, therefore, are more dynamic, since they allow more innovative articulations. However, this is an assessment only regarding the structural character of the network. The Table 3 below summarizes the main KWs of each cluster according to their IC.

Cluster 1 (n = 15): Special education; Students with disabilities; Social inclusion; Parents' attitudes; Supplementary and/or alternative communication; Technology; Technical and pedagogical strategies; ADHD; Life's history; Sport for the disabled; Assisted evaluation; Socialization; Activities of daily living; Psychomotor development; Supplementary and/or Alternative Communication.
Cluster 2 (n = 51): Regular education; Down syndrome; People with disabilities; Deafness; Cerebral palsy; Families; Physical Education; Evaluation; School inclusion; Language; Physical disabilities; Accessibility; ASD; University education; Architectural barriers; Mothers; Children; Sign language; Bilingualism; Reading; Intelligence; Children with disabilities; Attentional deficits; Communication; Stress; Assistive technology; Early Childhood Education; Language disorders; Social interaction; Physiotherapy; Educational technology; Occupational therapy; Quality of life; Psychometrics; Parental guidance; Siblings; Caregiver; Children's language; Self-perceptions; Assessment tools; Literacy; Indigenous education; Early stimulation; Musical education; Health professional; Family education; Children drawing; Student participation; School furniture; Family participation; Child care.
Cluster 3 (n = 30): Special needs; Vision disorders; Visually impaired children; Motor development; Intellectual disability; Motor skills; Sexuality; Sexual education; Pedagogical practices; Language development; Speech therapy; Games and toys; Written language; Body; Writing; Mother-child interaction; Child development; Intervention; Blindness; Physics teaching; Play; Human development; Skills assessment; Social perception; Interaction; Motor evaluation; Communication system; Risk; Developmental psychology; Body image.
Cluster 4 (n = 22): Inclusion; Disabilities; Teacher training; Special educational needs; Social representations; Public policies in education; Hospitalized children; Education of people with disabilities; Specialized educational service; Humanization; Social attitudes; Orofacial cleft; Service in resource room; Genre; Distance education; Communication systems; Resource room; Hospital class; Citizenship; Special classes; Curriculum; Family relationships.
Cluster 5 (n = 17): Inclusive education; Elementary School; Teachers; Conception; Attitudes; Perception of competence; Adapted physical education; Training; Deaf students; Behavior problems; Professionalization; School consultancy; Historical-cultural theory; Teacher-student interaction; Motricity; Itinerant teacher; School organization.
Cluster 6 (n = 5): Gifted students; Brazilian sign Language; Identity; Teaching; High school.
Cluster 7 (n = 6): Mental disability; Observations; Dialogue; Phonological awareness; Psychology; Social skills.
Cluster 8 (n = 7): Hearing impairments; Schooling; Adolescence; Semiotic mediation; Childhood; Rehabilitation of the disabled; Reading and writing.
Cluster 9 (n = 5): Parents; Learning difficulties; Deafblindness; Mathematics teaching; Learning.

Cluster 10 (n = 3): Special education institutions; Youth and adult education; Public policies.
Cluster 11 (n = 1): Scientific production.
Cluster 12 (n = 1): Work.

Table 3. Main keywords in each group with intermediation centrality above 0.001.

The Table 3 shows that, in many of the clusters, there are underlying main themes. Particularly in the cluster with greater dynamics (2), there is an integration of aspects, variables, methods, concepts, disabilities, which are related to the issue of school inclusion in regular education (KWs with higher IC in the group). This is the area of greatest challenge at the same time and it is not surprising for its dynamics of intercrossing issues in the knowledge network. As an example, the papers published in the *RBEE* and their respective citation in Google Academic until March/2019 stand out in this line: "School inclusion, teacher training and consultancy based on educational social skills" (Rosin-Pinola & Del Prette, 2014 - cited 39 times), "Assisted assessment for children with special educational needs: an auxiliary resource for school inclusion" (Enumo, 2005 - cited 81 times) and "Pedagogical action and special education: the resource room as a priority in the provision of specialized services" (Baptista, 2011 - cited 107 times), which discuss the challenges imposed to the implementation of strategies in the school environment, from the provision of educational services and resources to the actions of educators for the effective inclusion of students with different types of disabilities, with a view of breaking with the traditional teaching model.

In another perspective, it is possible to verify some pairs of KWs more frequently associated with the knowledge network (Figure 4 below). The recurrence informs about the tradition of association between the themes involved. As it is possible to verify by the high value of IC of the keyword Special Education, many associations between themes are intermediated through this keyword. However, it is possible to verify that, in addition to the intermediation power exercised by the keyword Special Education, there are other interchanges independent of this that are carried out between the KWs Assistive Technology, Cerebral Palsy, Inclusive Education, Deafness and Brazilian Sign Language; and between Down Syndrome, Families and Inclusion.

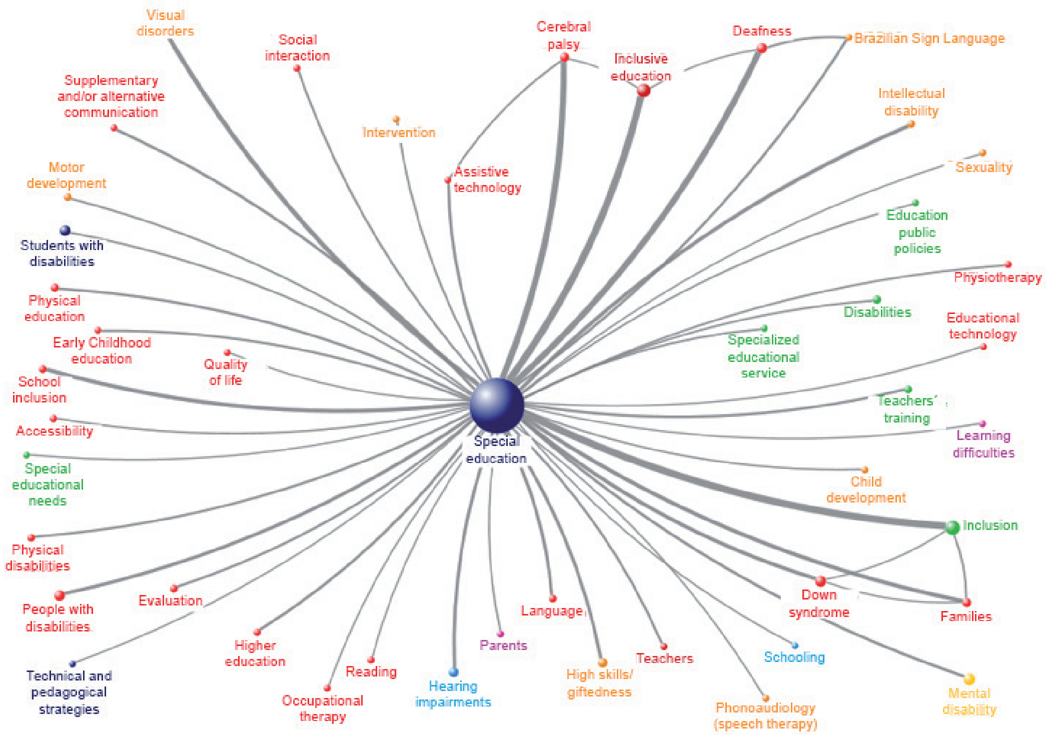

Figure 4. Pairs of keywords repeated over 4 times in the knowledge network.

In Figure 4, it can be seen that the KWs have different sizes - in this case, the larger the size of the vertex, the greater its intermediation power. This type of centrality indicates the vertices located in a position of intermediation to other vertices. In the investigated network, the degree of participation of the most important KWs is presented, with the function of establishing links with other KWs or subgroups, acting as important elements in this structure.

The recurrence of association between KWs indicates specific niches of the publication knowledge network in the *RBEE*; the line thickness indicates more intense recurrences of association of KW pairs, which, in this case, are more outstanding with the keyword Special Education (Inclusion; Deafness; Inclusive Education; Intellectual Disability; Cerebral Palsy; Vision Disorders; School Inclusion and People with disabilities). As can be seen, half of the major recurrences refer to disabilities. These are the most intersected thematic fields. The striking association between these keywords creates semantic fields with a greater tradition of research.

4 Final considerations

This research aimed to identify, in an exploratory way, the knowledge network developed in the *Revista Brasileira de Educação Especial* (*RBEE*), through the description of the structural relational pattern and some network metrics. More and less explored themes were identified in the literature and research tendencies. The analysis of the literature developed here was that of a knowledge network, using keywords with the use of mathematical models (Graph Theory, SNA), which present important aspects in understanding the associations of the various scientific fields, as it denotes an active articulation of cooperation and flow of exchanges between individuals and/or institutions, is a derivation, a by-product of social networks.

The total network found has a scale-free profile, with a modular and hierarchical structure according to the model described by Lee, Su and Chan (2010). This structural pattern seems to be at the center of the organization and evolution of scientific knowledge, which indicates a structure organized in clusters so that there are preferential associations. Applying the CNM algorithm, 18 knowledge network organization clusters were found, of which 12 are part of a single component, 95% of the network's KWs. Thus, there is an area unit involved in the journal's network, however marked by subareas. These clusters have different profiles so that the keyword Special Education centralizes this field of knowledge that is in its surroundings with a disparity in the Intermediation Centrality of other KWs. In other clusters, the knowledge network is more dynamic, with a greater intercrossing of areas, given the better distribution of IC among the component KWs.

In any case, the keyword Special Education represents more than five times the centrality of degree of the second keyword (inclusive education). It is assumed that this result may be a bias in the journal's own editorial line. The main disabilities that mediate the knowledge network ranked by intermediation score are: mental disability, Down syndrome, deafness, vision disorders, hearing impairment and cerebral palsy. This thematic order reflects the research preferences on disability presented in the *RBEE*. Thematically, these disabilities move around teaching and education categories (special education, inclusive education, regular education, gifted students, students with disabilities, elementary school, special classes, curriculum); of fundamental concepts and rights and contexts involved (inclusion, people with disabilities, special needs, work, families. Considering the power of intermediation, the special education niche is the main mediator; at a lower level would be the disabilities, which, in turn, are mediated by issues of teaching and education, which are mediated by issues of fundamental rights and contexts, such as work and family.

The importance of this study lies in examining the patterns of structural interactions existing in the network, which, in addition to identifying the most recurring themes, found an expressive number of themes that are associated and that appear as pairs in several papers, highlighting the culture of association among the themes involved, the tendency to dialogue and constant interdependence between them. Due to space limitations, in this paper, KWs with higher ICs that represent the most explored themes in the journal stood out, a circumstantial cutoff of the knowledge network. Other KWs with a lower IC play a peripheral role in the network. However, these same KWs are frontier areas, depending on the dynamics of the network, which can assume a more central role. Due to the relevance of this type of discussion, one must invest in this area of investigation.

The conclusions of this research must also be understood through its limitations. The main one refers to the option of working only with keywords, which should be conceived as an exploratory "entry" investigation, which specifies the structure of knowledge, the Knowledge Network. Although the results of this review provide some relational patterns that bring together the network of themes addressed in Special Education, it is important to develop new studies on the subject in order to broaden the understanding of how the associations of the various scientific fields are being built through of a network phenomenon.

Another limitation refers to the cutoff configuration of the total network, considering a wide range of years (1992-2017). As it is a macro analysis, it disregarded narrower year ranges. Evidently, during this period, there were superstructural changes (for example, public policies), which possibly impacted the development of the network itself. An analysis of networks over a shorter period of years, which may possibly be related to events of a socio-political nature, can assess the correlation of the knowledge network with other broader superstructures that are supposedly correlated to it. These are certainly necessary continuities of this work.

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