



Analysis of keyword networks of electronic scientific journal

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ABSTRACT

Information science faces challenges in addressing the ever-growing, deterritorialized, and increasingly complex digital environment. New methodological approaches are needed to effectively analyze the diversity of contemporary networks and information systems. This study employed bibliometric and network analysis to examine trends and highlight frequent keywords within a scholarly electronic journal, *Informação & Informação*. The analysis quantitatively and visually mapped the relationships between keyword frequency and co-occurrence within the journal's corpus. Data, spanning four decades, were grouped and analyzed using keyword network maps. While "information science" emerged as a prominent keyword, its relevance in published research became particularly pronounced in the first decade of the 21st century. The analysis also revealed a considerable expansion of research themes over time, with "knowledge organization," "knowledge management," "information management," and "scientific communication" appearing as particularly relevant topics.

Keywords: network analysis; co-occurrence of keywords; bibliometrics; journal *Informação & Informação*.

INTRODUCTION

Understanding how knowledge is organized is crucial to grasping the nature of scientific knowledge and its impact on society. To meet the challenges of an increasingly complex, decentralized, and rapidly growing digital environment, Information Science must embrace diverse methodologies capable of handling the wide variety of information systems and networks that exist today.

While social networks are built on relationships between individuals, groups, or organizations, keyword networks arise from the relationships between words. When these words appear in an article, sentence, or message, they form distinct connections, potentially revealing previously hidden relationships.

Analyzing keyword networks derived from published scientific articles – the focus of this study – provides insights into key research topics, emerging trends, and developments within a field. It also sheds light on the relationships between researchers and the themes they explore.

In this context, this study aims to investigate trends and identify the most frequently used keywords in the domain of an electronic scientific journal by analyzing the scientific networks these keywords create.

Keywords in the electronic scientific journals

A scientific journal, as defined by Lara (2006, p. 405), serves as a formal communication platform organized into issues or volumes, primarily containing scientific articles. These articles are published at regular intervals, intended for indefinite circulation, with wide dissemination. This format is grounded in the principle of validating merit and scientific methodology through peer review, ensuring the approval of submitted texts for publication.

In electronic formats, the structure of scientific articles takes the form of hypertext, enabling links to other documents and the integration of audiovisual resources, such as images, audio, and video. This format allows readers to navigate the sources and data referenced by the authors (Lara, 2006, p. 406).

Keywords, in turn, are significant words or short phrases that describe a work's content using natural language. These terms, which are flexible and vary according to the user's vocabulary (Muñoz-Martín, 2016), are assigned by authors to succinctly represent the thematic content of their texts. Since authors possess an undeniable informational mastery of their work, stemming from the creative process, keywords should reflect their area of expertise. In this way, keywords function as tools for both information representation and retrieval (Borba; Van der Laan; Chini, 2012).

According to Fujita and Tartarotti (2020, p. 336), a keyword represents the meaning of verbal or non-verbal content and serves multiple purposes, including bibliometric studies, indexing, and information retrieval. However, its primary role is to identify central ideas and themes.

Miguéis *et al.* (2013, p. 15)¹, argue that keywords have become essential for representing, searching, and retrieving information in journal articles. They optimize access to content by going “[...] além da informação representada pelo título e resumo; traduz o pensamento dos autores, e mantém o contato com a realidade da prática cotidiana, acompanhando a evolução científica e tecnológica, refletida pelos documentos”.

The term “keyword” is often used interchangeably with “descriptor” in the literature. However, from a documentary perspective, this equivalence is not entirely accurate. As Brandau, Monteiro, and Braille (2005) observe, descriptors are organized hierarchically, facilitating systematic research and retrieval, whereas keywords lack structure, are drawn from natural language, and appear more randomly. To transition from keyword to descriptor status, a term must undergo rigorous control, ensuring synonym accuracy, semantic precision, and relevance within a specific subject area taxonomy.

Descriptors are terms from natural language that, after a selection process, become part of a thesaurus’s controlled vocabulary. To achieve descriptor status, a term must be the most representative of the concept it represents within the thesaurus. By selecting one term as the sole valid representative among many with identical or nearly identical meanings, we achieve the univocal nature of documentary language. A descriptor, therefore, uniquely represents a concept in documentary language (Martín Gavilán, 2009).

Documentary languages, or controlled vocabularies, are traditional tools for information representation. They facilitate communication by standardizing terms used to describe document content (Santos, 2017). When processing an article for a database, an information professional assigns standardized terms based on the document’s subject matter to ease retrieval. This process is known as indexing (Muñoz-Martín, 2016).

Indexing involves concisely describing a document’s content using terms—also called keywords or descriptors—that serve as access points for identifying and retrieving the document (Santos, 2017).

Keywords and descriptors share the use of natural language and the function of representing concepts. However, keywords are subject to the variability and ambiguity of natural language (e.g., gender, number, synonymy, polysemy) and lack control over associative and hierarchical relationships. Descriptors, in contrast, are characterized by semantic relationships and greater control (Martín Gavilán, 2009).

In bibliometric research, keywords extracted from scientific publications are fundamental for representing knowledge concepts. Su and Lee (2010) note that they are commonly used to reveal the knowledge structure of research domains.

1 Translation: “[...] beyond the information represented by the title and abstract; they translate the authors’ thought processes and maintain contact with the reality of daily practice, keeping pace with scientific and technological advancements reflected in the documents” (Miguéis *et al.*, 2013, p. 15, editorial translation).

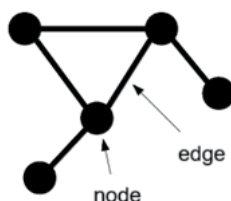
Therefore, we can infer that metric studies are applicable in various contexts where quantitative resources serve as analytical tools. These studies generate indicators that allow for the evaluation of growth, dispersion, decline, and emerging interests in contexts such as university libraries.

Depending on the research objectives, there are two distinct approaches to using keywords: 1) Using all keywords to explore the structural characteristics of domain knowledge at a macro level. This approach often employs techniques like social network analysis of scientific competence networks (e.g., keyword networks); and 2) Using selected “important” keywords to analyze specific research topics within a domain and their relationships at a micro level (Chen; Xiao, 2016).

NETWORK OF KEYWORDS

Networks provide a versatile and effective way to represent patterns of connections or interactions among components within a system. At their simplest, networks consist of points connected in pairs by lines. In the terminology of network theory, these points are referred to as vertices or nodes, and the lines as edges, as illustrated in **FIGURE 1** (Newman, 2010).

FIGURE 1 – Illustration of a Network



Source: Prepared by the authors (2022).

In complex network theory, a network corresponds to a graph. Barrico (1998, p. 13)² defines a graph as a “[...] representação visual de um determinado conjunto de dados e da ligação existente entre alguns dos elementos desse conjunto”. He argues that for many problems, a visual representation in the form of a graph offers a more comprehensible and effective approach to constructing a mathematical model.

In this study, the keywords intentionally selected by authors of scientific articles are treated as nodes within a chain of relationships. These keywords are linked to others associated with scientific articles in the same repository, forming a graph that can be analyzed using theoretical tools from network analysis. This approach allows researchers to achieve higher levels of abstraction and modeling. Specifically, in this study, the nodes represent keywords from articles published in the journal *Informação & Informação*, and the edges represent co-occurrence relationships among these keywords within the journal’s bibliographic corpus.

2 Translation: “[...] visual representation of a given dataset and the connections among its elements”. (Barrico, 1998, p. 13, editorial translation)

Choi, Yi, and Lee (2011, p. 373)³, highlight two key characteristics of keyword networks: “ (1) é uma rede não direcionada (os links entre os nós são simétricos) e (2) é uma rede ponderada (ou seja, um link entre duas palavras-chave é numerado) - mostra quantas vezes as duas palavras-chave aparecem na rede: esse número mostra a força da conexão”. To understand the characteristics of keyword networks, researchers use several well-defined and widely used metrics. These include degree centrality, which is the number of neighboring nodes to which a focal node is connected; betweenness centrality, which measures the extent to which a node lies on the paths between other nodes; characteristic path length, which is the average length of all the shortest paths between pairs of nodes; clustering coefficient, a network-level measure that illustrates the tendency of nodes to form densely interconnected modules; and network density, which is calculated by dividing the number of connections in the network by the number of all possible connections (Choi; Yi; Lee, 2011).

Expanding on these definitions, Popescu *et al.* (2014) explain that the degree of a node equals the number of edges (pairs of keywords) connected to it and can be normalized as degree centrality. A node with high centrality has many connections and may indicate links between themes that share ideas or address different topics using similar methods. The more connected a keyword, the more central it becomes.

Betweenness centrality measures the extent to which a node lies on the shortest paths between other nodes. Distance centrality for a given keyword is measured as the number of shortest paths passing through it, divided by all the shortest paths in the network. This metric helps identify keywords that act as bridges, connecting otherwise distinct nodes. Such keywords may have lower degree centrality but function as connectors between subfields or types of studies.

RELEVANT LITERATURE

Metric studies of information offer interdisciplinary possibilities by analyzing domains through various techniques such as network analysis, statistical indicators, graph theory, and cluster studies. These methods extract various indicators to uncover objective and measurable knowledge structures within selected domains (Oliveira, 2018). This section presents some relevant and recent works related to keyword networks, drawing from both national and international literature.

Gomes, Dias, and Moita (2018) mapped the main research topics of Brazilian science based on the keywords of scientific articles authored by scholars with curricula available on the Plataforma Lattes. They collected data from conference proceedings and journals registered in this database, covering 1962 to 2016. Their results were presented using bibliometric analyses based on frequency and social network analysis techniques applied to the articles' keywords.

³ Translation: “(1) they are undirected (the links between nodes are symmetrical), and (2) they are weighted (a link between two keywords is numbered) – this number indicates how often the two keywords appear together, representing the strength of the connection”. (Choi; Yi; Lee, 2011, p. 373, editorial translation).

Sánchez-Tarragó, Santos, and Bufrem (2018) investigated the domain configuration of the Internationalization of Higher Education, focusing on the spatial distribution of Brazilian scientific output and researcher networks. Employing a domain analysis methodology, they combined bibliometric techniques with social network analysis to characterize the structure of co-authorship networks and the relationships between keywords, authors, and institutions.

Analyzing the evolution of keyword co-occurrence in *The Microsoft Academic Graph* (MAG), Zhan, Dong, and Ye (2018) noted that the emergence of a new “hot” keyword signifies that knowledge has entered a new domain, uncovering a new problem. Conversely, the disappearance of a keyword reflects a resolved issue or an outdated technique. As an example, they highlight the keyword “gamma radiation,” which first appeared in 1900 when humanity discovered a new form of penetrating electromagnetic radiation. It only garnered significant attention in the 1950s with the creation of the atomic bomb, peaked in research interest in the 1970s, and subsequently declined in relevance.

To further develop the methodology of keyword networks, Yi and Choi (2012) constructed and analyzed the keyword networks of three major journals in business research. The authors identified two major challenges in keyword network analysis: computational load, as articles often include numerous keywords, leading to large datasets that require proportional computational capacity; and the difficulty of identifying keywords, as they are typically provided by authors and may appear in various forms. They emphasize the need for a systematic literature approach in keyword network analysis to better understand how scientific and technological knowledge is organized.

Figuerola *et al.* (2021, p. 83) examined the Web of Science database in the field of Library and Information Science from 1971 to 2020. They analyzed the keywords used by authors to describe their scientific articles and concluded that network analysis techniques, supported by the appropriate tools, can substantially aid in deepening the understanding of the thematic structure and evolution of a knowledge domain.

In their effort to identify and analyze articles related to measuring the bioeconomy, with a focus on its economic, social, and environmental impacts, Ferreira, Fabregat-Aibar, Pié, and Terceño (2022) conducted a detailed descriptive analysis of publication trends and a relational analysis of keyword and author collaboration networks. Among other conclusions, they highlighted that visualizing the keyword network provides an overview of the study theme related to bioeconomy impact analysis, clearly distinguishing studies focusing on socioeconomic and environmental impacts.

Moresi, Lemos, and Hedler (2021) presented a bibliometric analysis of organizational ambidexterity and innovation, exploring the co-occurrence of keywords and the co-citation of references. Their analysis of the co-occurrence network revealed the most relevant concepts in research on this theme, while the co-citation network enabled the identification of research frontiers. The study concluded that these types of analyses highlight the strong relationship between the themes of ambidexterity and innovation and their influence on organizations’ adaptive capacity.

METHODOLOGICAL STRATEGY

To achieve the proposed objectives, we conducted a bibliometric and network analysis to quantitatively and visually examine the relationships between co-occurring keywords. We selected the journal *Informação & Informação* as the bibliographic corpus for this analysis.

Informação & Informação is an open-access electronic scientific journal published quarterly by the Graduate Program in Information Science (PPGCI) at the Department of Information Science, Universidade Estadual de Londrina (UEL). It holds an A2 classification in the CAPES Qualis system and is one of the leading scientific journals in the field of Information Science in Brazil. Since its inaugural issue in 1996, the journal has published 27 editions, totaling 829 articles and 3,455 author-assigned keywords (through the first quarter of 2022).

The construction of the keyword network involved several stages, as illustrated in **FIGURE 2**, including data extraction, refinement, and the subsequent generation, visualization, and analysis of keyword maps. VOSviewer (Van Eck; Waltman, 2022), a software tool designed specifically for bibliometric network analysis, was used to create the keyword network maps, enabling the construction of various network types.

FIGURE 2 – Procedures for Keyword Network Analysis

STEP	PROCESS	DETAILING AND STANDARDIZATION OF THE PROCESS
1 Data Extraction	Extraction of keywords from articles published in the journal <i>Informação & Informação</i> from 1996 to 2022	• Systematization of data in an Excel spreadsheet.
2 Data Refinement	Standardization of keywords extracted from the corpus of articles published in the journal	• Removal of redundant keywords; • Grouping and standardization of words; • Comparison and verification of keywords according to the controlled vocabulary of the journal.
3 Network Visualization	Division of keywords into four different decades: 1996 - 2000 2001 - 2010 2011 - 2020 2021 - 2022	• New systematization in an Excel spreadsheet based on annual intervals; • Data organization for insertion into the VOSviewer tool; • Insertion of keywords into a WordCloud tool.
4 Centrality Analysis	Generation of the network with the determination of the importance of keywords based on node degree centrality	• Comparison of data with the word cloud obtained with the WordCloud tool; • Creation of keyword network maps in the VOSviewer tool; • Exploration of network data to allow quantitative and qualitative analysis from the visualization.

Source: Prepared by the authors (2022).

After refining and consolidating the keyword database, the final dataset comprised 3,455 keywords, including 1,684 unique keywords. **TABLE 1** displays the distribution of the total number of articles and keywords by decade. We presented the data in ten-year intervals (despite the incomplete decades) to facilitate visualization and understanding of the terms used over time.

TABLE 1 – Number of Articles Published and Keywords (1996–2022)

Period	Articles	Unique Keywords	Total Keywords
1996-1999	39	98	132
2000-2009	121	326	477
2010-2019	438	1050	1874
2020-2022	231	627	972
Total	829	2101	3455

Source: Prepared by the authors (2022).

It is worth noting that *Informação & Informação* has undergone changes in publication frequency throughout its existence. From its inception in 1996 until 2012, issues were published semiannually, with the addition of an annual thematic issue starting in 2007. From 2013 to 2019, the journal adopted a four-month publication cycle, and since 2020, it has been published quarterly. Consequently, the initial decade of publication has fewer articles, while the last decade, despite including only two full years and one quarterly issue, offers a significant number of publications. This allows for the identification of current research trends in the field.

ANALYSIS AND DISCUSSION OF RESULTS

Keywords, when systematically collected, organized, and analyzed with temporal demarcations, offer valuable insights into the thematic domain of the journal *Informação & Informação* and the broader field of Information Science. This analysis also reveals theoretical and epistemological shifts across decades.

To highlight the most frequent keywords in the journal, **FIGURE 3** presents a word cloud for easy visualization. This figure displays the terms most frequently used by authors to describe the content of their articles.

FIGURE 3 – Word Cloud of Keywords from 1996–2022



Source: Prepared by the authors (2022).

TABLE 2 lists the keywords with frequencies of 21 or higher. As shown in both the word cloud and the table, “ciência da informação” (Information Science) is the most prominent term, followed by “informação” (Information) and “organização do conhecimento” (Knowledge Organization). This prominence is expected, given the journal’s focus on a specific domain of knowledge, and reflects the centrality of these concepts to the field. Other frequently occurring keywords illuminate key research areas within Information Science, shedding light on the field’s epistemological evolution and the knowledge it has produced over the years.

TABLE 2 – Frequency of Key Keywords (1996–2022)

Keywords	Frequency	Keywords	Frequency
Information Science	79	Information Mediation	25
Information	40	Information Professionals	24
Knowledge Organization	38	Information Literacy	24
Knowledge Management	33	Archival Science	24
Information Management	31	University Libraries	22
Scientific Communication	31	Bibliometrics	22
Social Networks	26	Information Retrieval	21
Information Organization	26	Library Science	21

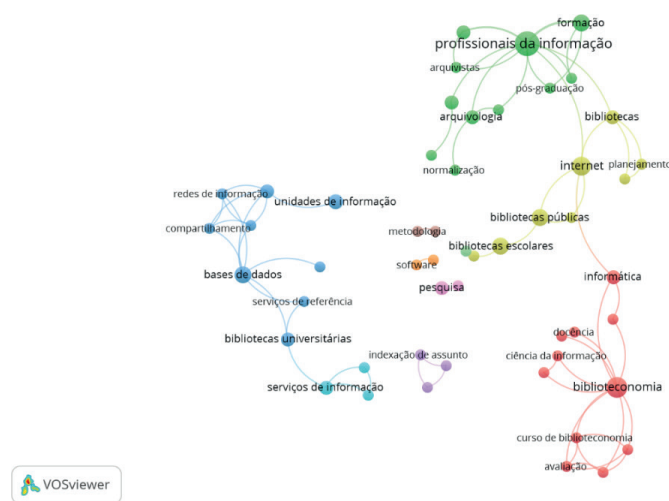
Source: Prepared by the authors (2022).

To enhance comprehension of the keyword network maps, a minimum frequency of two occurrences was set for a keyword's inclusion in the analysis. The size of the keyword's

circle and label on the map is proportional to its importance in the network. Keywords grouped by color represent clusters, formed based on affinity or proximity. Line thickness indicates the strength of connections between keywords..

The keyword network from 1996–1999 (**FIGURE 4**) highlights “profissionais da informação” (Information Professionals) and “biblioteconomia” (Librarianship) as central terms. Other noteworthy terms include “bibliotecas escolares” (School Libraries), “bibliotecas públicas” (Public Libraries), “unidades de informação” (Information Units), “base de dados” (Database), “formação” (Training), and “internet.”

FIGURE 4 – Keyword Network Map (1996–1999)



Source: Prepared by the authors (2022).

The network reflects the key themes of the decade, which are still connected to the context of the late 20th century and the ongoing challenges facing the field and information professionals in the new millennium. This is particularly true regarding their relationship with emerging technologies, as evidenced by the continued emphasis on the professional’s areas of practice.

For the period 2000–2009 (**FIGURE 5**), the most prominent nodes highlight “ciência da informação” (Information Science) and “gestão da informação” (Information Management) as the most frequent keywords, followed by “informação” (information), “redes sociais” (social networks), and “tecnologia da informação” (information technology).

While the map still shows some emphasis on “profissionais da informação” (information professionals) and “internet,” the scientific output during this decade shifted toward Information Science and Information Management. These areas were tasked with strengthening their theoretical and methodological foundations to address the social transformations brought about by new technologies. With digital technologies and networked communications becoming central to the field, new keywords such as “sociedade da informação” (information society) and “compartilhamento da informação” (information sharing) also gained prominence, reflecting their growing importance in the research landscape.

With the consolidation of Information Science as a field, its designation as a keyword in published articles has become expected. However, this decade also saw an increased emphasis on new themes. Two prominent examples are knowledge organization, which involves cognitive organization, knowledge systematization, and the development of knowledge organization systems; and information organization, which encompasses the physical and content description of information objects, with a focus on information records and their representation (Bräscher; Café, 2010).

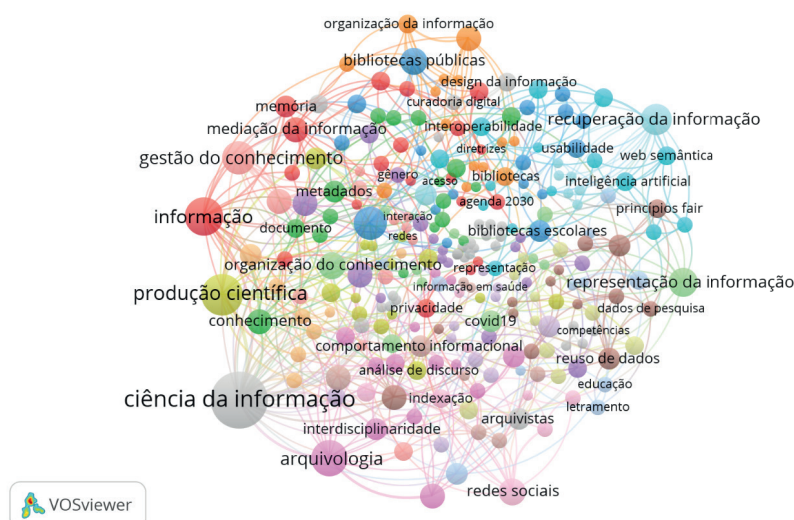
Studies on scientific communication, which examine the creation and dissemination of scientific knowledge through various communication channels, particularly scientific journals, also emerged as significant topics during the 2010–2019 period. Similarly, research on information mediation, focusing on the roles and actions of mediators in information retrieval and addressing user needs, gained prominence.

The prominence of certain keywords during this period may also reflect the publication of thematic issues by the journal. For example, topics such as knowledge organization and representation, scientific communication, information mediation, bibliographies, and innovation management were among the focal points of the decade. The emphasis on specific themes not only demonstrates their recognized importance but also underscores the journal's role in fostering debate and advancing research within the field.

At the start of the subsequent decade, covering 2020 to 2022 (**FIGURE 7**), the continued dominance of the keyword “information science” remains evident, followed by “scientific production,” “information,” “knowledge management,” and “archival science”.

In addition to the terms highlighted in the previous decade, this period saw increased emphasis on studies related to scientific production. This indicates the field's growing interest in understanding the contributions of its researchers and its scientific domain to knowledge production in Brazil and globally.

FIGURE 7 – Keyword Network Map (2020–2022)



Source: Prepared by the authors (2022).

Also noticeable in this period is the growing presense of the keyword “archival science,” which ranks fifth in occurrence. This reaffirms its current interconnectedness with Information Science and its establishment as a scientific discipline.

CONCLUSION

The keyword networks, along with the highlighted terms across different decades, effectively reflect the structure and evolution of scientific knowledge in Information Science. They also underscore the crucial role of careful keyword selection in accurately representing research content.

The main trends identified in *Informação & Informação* provide a historical perspective on the evolving interests and concerns of researchers and the scientific community regarding the informational challenges of the field. This further highlights the value of keyword analysis in understanding the development of a field.

Although “information science” stands out as the principal keyword, it was only in the first decade of the 21st century that the term gained substantial prominence in published research. The analysis also revealed a considerable expansion of research topics over time, with “knowledge organization,” “knowledge management,” “information management,” and “scientific communication” emerging as particularly relevant themes.

The data systematized in this study offer a wide range of possibilities for future research. These include associating keywords with article authors, their institutions, and locations, as well as conducting co-authorship network analyses and exploring other related aspects to gain deeper insights into the field’s dynamics.

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