KNOWLEDGE SHARING THROUGH RESEARCH COLLABORATIVE NETWORKS

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*Abstract***:** *Research collaboration is key to creating new solutions and achieving better results in education. Science is done by collaborative teams, and their organizational unit has changed from individuals to Research Collaborative Networks. With the support of digital technologies and real-time access to information, knowledge sharing in interest areas is spreading. The purpose of this article was to analyze how knowledge sharing occurs in the context of these networks. For this, an integrative literature review was conducted. The analysis of this field shows that the need to innovate added to scientific development has established networks that overcome geographical boundaries in the knowledge dissemination. Researchers need to share their research outputs with broader audiences on a larger scale. It is necessary to communicate science in a more attractive and effective way.*

*Keywords***:** *Research Collaborative Network*; *Knowledge Sharing*; *Scientific Dissemination*; *Knowledge Flow; Social Network Analysis*.

Resumo: A colaboração na pesquisa é fundamental para criar novas soluções e alcançar melhores resultados na educação. A ciência é feita por equipes colaborativas e sua unidade organizacional mudou de indivíduos para as Redes Colaborativas de Pesquisa. Com o auxílio das tecnologias digitais, o compartilhamento de conhecimentos em áreas de interesse se propaga. Este artigo teve como objetivo analisar como o compartilhamento de conhecimento ocorre no contexto destas redes. Para tal, foi realizada uma revisão integrativa da literatura. A análise desse campo mostra que a necessidade de inovar somada ao desenvolvimento tem estabelecido redes que ultrapassam fronteiras geográficas na disseminação do conhecimento. Pesquisadores precisam compartilhar seus resultados de pesquisa em uma escala maior. É preciso comunicar a ciência de uma maneira mais atrativa e eficaz.

Palavras-chave: Rede Colaborativa de Pesquisa; Compartilhamento de Conhecimento; Divulgação Científica; Fluxo de Conhecimento; Análise de Rede Social.

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1 INTRODUCTION

In recent years, a broad consensus on the notion that science is done in collaborative teams has been built (Vacca *et al.*, 2015). Research collaboration is fundamental to exploring, creating, and developing new ideas and solutions (Zamiri *et al.*, 2019). It is a prerequisite for achieving good results in science and education (Grba & Mestrovic, 2018). Thus, pursuing scientific research collaboration among teams has become the most important task in promoting scientific research and an effective way to solve many of today's major problems. In addition, scientific research collaboration also plays a crucial role in formulating science and technology policies (Zhao *et al.*, 2021).

A growing body of evidence shows that the most impactful work and the most innovative inventions in contemporary science come from more interdisciplinary teams. Higher Education Institutions (HEIs), government agencies, and public and private sector research centers increasingly recognize that most of the problems we face today are complex and need to be addressed by interdisciplinary teams (Vacca *et al.*, 2015; Zamiri *et al.*, 2019; Zhao *et al.*, 2021).

In this perspective, the typical organizational unit of science has changed from individuals to the establishment of Research Collaborative Networks (RCNs) in all areas of knowledge (Haddad, Mena-Chalco & Sidone, 2017). The sharing of knowledge captured in the RCNs enhances processes within the organization, maintaining a continuous cycle of effective information and knowledge to achieve better results (Inomata, 2017).

In this context, this work aims to analyze the characteristics of recent years on knowledge sharing through RCNs, to identify trends and thematic gaps in publications indexed in international databases. Based on this analysis, this study seeks to verify how knowledge sharing occurs in the RCN context. The following sections are organized as follows: section 2 presents the background. Section 3 describes the methodology used. Section 4 presents the results found, discusses the approaches and trends. Finally, the final considerations are presented in section 5.

2 BACKGROUND

Collaborative networks result from diversity, internationalization that integrates people, knowledge, skills, and methodologies around a shared cognition (Leite & Pinho, 2016). A collaborative network is defined by Camarinha-Matos & Afsarmanesh (2008) as "an alliance consisting of a variety of entities (e.g., organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating

environments, culture, values, and goals, but that collaborate to better achieve common or compatible goals, and whose interactions are achieved through computer networks." In this line, Leite & Pinho (2016) emphasize that the development of RCN is essential to achieve excellence in scientific dynamics.

The RCN is one of the most representative complex networks (Zhao et al., 2021), since it allows the existence of a dynamics of relationships between researchers, institutions, and countries that develop an academic work or a project, whose joint publications represent one of the clearest ways to record collaborative relationships in the scientific environment. Research collaboration is one of the main mechanisms for the dissemination or sharing of knowledge, one of the three major stages of the Knowledge Management (KM) process (Dalkir, 2017), and is closely associated with a higher quality of scientific production (Haddad, Mena-Chalco, & Sidone, 2017; Santa Anna, 2017).

KM manages the processes that govern the creation, sharing, and use of knowledge by blending technologies, organizational structures, and people to create learning, problem solving, and more effective decision-making (adding value) in an organization (Firestone & McElroy, 2005; Dalkir, 2017). From this perspective, scientific knowledge can also be subdivided into tacit and explicit. The explicit case refers to any form of codified, easily structured knowledge that can be communicated by structured systems or formal means, comprising scientific literature (Souza, 2019).

Finally, it is worth noting that with the aid of digital technologies and near-real-time access to information, the sharing of knowledge in areas of interest and study relevance, in similar fields, is propagated. The most developed societies live on information, and digital technologies keep them oxygenated. These societies are characterized as Knowledge Societies, due to the large production and dissemination of data, information, and knowledge (Lima; Bastos & Bastos, 2020). With collaboration tools, in the digital age, knowledge sharing among professional and social peers has become independent of space and time (Hina, Dominic & Ratnam, 2016).

3 METHODOLOGY

This study is based on an integrative literature review about the forms of knowledge sharing through RCNs. In an integrative review, researchers objectively criticize, summarize, and draw conclusions about a subject. This occurs through systematic research, categorization and thematic analysis of previous qualitative and quantitative research on the subject (Lobiondo-Wood & Haber, 2017). The searches occurred in the Scopus, Web of Science

(WoS) and Scielo databases in May 2021. The database searches used the keywords presented in Table 1. The search was realized by topic, that is, the title, the abstract and the keywords of the records were analyzed.

In the initial search 36 records were found in the databases. Then, the articles were grouped by database and imported into the Mendeley software, where 12 duplicates were removed totaling 24 articles. Figure 1 presents the flowchart of the research process and article selection strategy. The abstracts of the articles were read and 7 studies were eliminated because they only tangency on the topic or were considered outside the scope of this review, remaining 17 articles for full reading, which represent the final sample of this work.

Table 1 – Search terms

Database	Keywords
Scopus	((scien* OR knowledge) W/0 (shar* OR disseminat* OR diffusion)) AND ((collaborat* W/0 network*)) W/1 (academic OR scientific OR research OR scholar* OR educat*))
WoS	((scien* OR knowledge) NEAR/0 (shar* OR disseminat* OR diffusion)) AND ((collaborat* NEAR/0 network*)) NEAR/1 (academic OR scientific OR research OR scholar* OR educat*))
Scielo	((scien* OR knowledge) AND (shar* OR disseminat* OR diffusion)) AND (("collaborative network" OR "collaboration network") AND (academic OR scientific OR research OR scholar* OR educat*))

Source: Elaborated by the authors.

Figure 1 – Flowchart of the research process
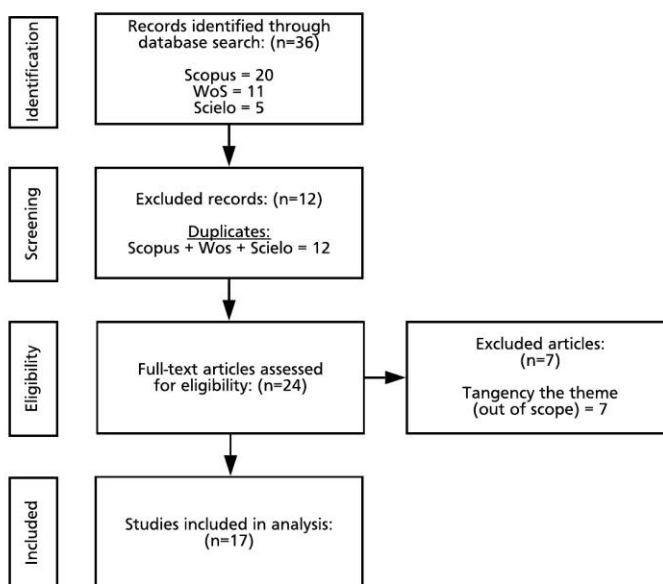
Source: Elaborated by the authors.

Previously, the articles were tabulated in a synthesis matrix (Garrard, 2016), using a spreadsheet to identify similarities based on the respective objectives, considering the knowledge dissemination in the context of RCNs. Finally, in order to group similar

documents into clusters, the selected documents were analyzed by the Orange tool (Orange, 2021). For this task, document titles, abstracts and keywords were used. Cosine similarity was used to measure the similarity between the vectors, along with the Ward hierarchical clustering method, represented by a dendrogram.

4 RESULTS AND DISCUSSION

This section presents and discusses the results found. The perspectives on knowledge sharing through RCNs are highlighted at the end of this section.

4.1 ANALYSIS OF RESULTS

The selected publications took place between the years 2008 and 2021. About 65% of the sample was published in the last 6 years. Figure 2 presents the number of selected articles distributed by year of publication. Figure 3 presents the dendrogram resulting from this document grouping analysis. Considering the titles, abstracts, and keywords of the articles, with the support of the Orange tool, it was possible to obtain the word cloud of the selected publications, as highlighted in Figure 4.

Figure 2 – Selected articles by year of publication

Source: Elaborated by the authors.

Figure 3 – Dendrogram of selected documents
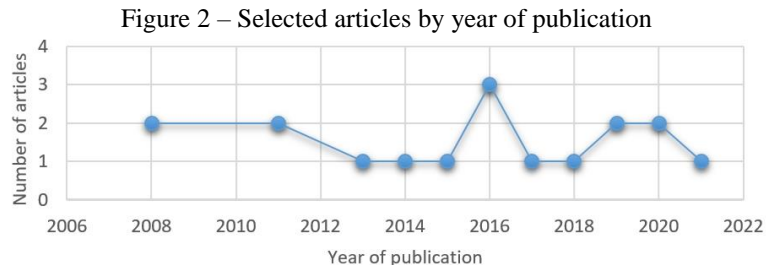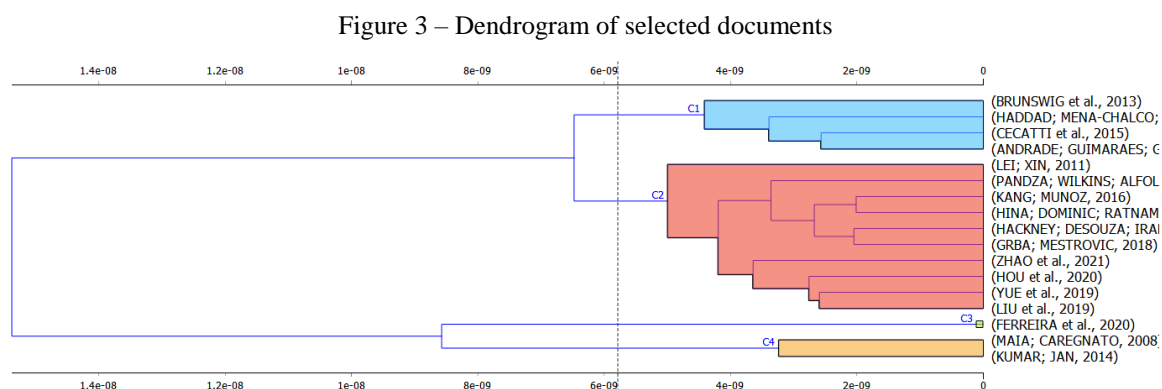
Source: Elaborated by the authors.

The most cited articles in the sample were written by Pandza, Wilkins, and Alfoldi (2011), with 48 citations in Scopus, and Hackney, Desouza, and Irani (2008), with 11

citations in Scopus and 7 in WoS. Table 3 presents the 4 clusters identified by the tool, organized into 3 groups, and the list of selected articles by group. The first group, *cluster 01*, is formed by 4 studies, which deal mainly with the dissemination of knowledge, with approaches to co-authorship and Social Network Analysis (SNA). The second group, *cluster 02*, presents 10 studies, which mainly discuss aspects of collaboration, with approaches dealing with SNA and knowledge flow. Finally, the third group, *clusters 03 and 04*, presents 3 studies that deal mainly with aspects of co-authorship, in addition to SNA.

Figure 4 – Word cloud of selected documents

Source: Elaborated by the authors.

Table 3 – Groups of selected documents

Cluster	Articles
01	(Brunswig *et al.*, 2013; Cecatti et al., 2015; Andrade, Guimarães & Galvão, 2016; Haddad, Mena-Chalco & Sidone, 2017)
02	(Hackney, Desouza & Irani, 2008; Lei & Xin, 2011; Pandza, Wilkins & Alfoldi, 2011; Kang & Munoz, 2016; Hina, Dominic & Ratnam, 2016; Grba & Mestrovic, 2018; Yue *et al.*, 2019; Liu *et al.*, 2019; Hou *et al.*, 2020; Zhao *et al.*, 2021)
03 and 04	(Maia & Caregnato, 2008; Kumar & Jan, 2014; Ferreira *et al.*, 2020)

Source: Elaborated by the authors.

4.2 PREVIOUS CONSIDERATIONS

Based on the similarities found in the respective objectives and considering the knowledge sharing through RCNs, this section analyzes each category in more depth. Table 4 presents the studies by identified group.

Table 4 - Highlights of selected studies by identified group

#	Study highlights
Cluster 01	▪ The academic network involving former students of the *Regional Economics Applications Laboratory* (*REAL*, a cooperative venture headquartered in the United States), who work at the academy in Brazil, was analyzed by Haddad, Mena-Chalco, and Sidone (2017). They analyzed patterns of research collaboration among Brazilian researchers, whose main activities are related to HEIs in Brazil. The Brazilian REAL network reflected the pattern of evolution of RCNs in emerging economies. Furthermore, the expansion of the network proved to be a relevant mechanism for the dissemination of knowledge in peripheral regions of the country. ▪ Andrade, Guimarães, and Galvão (2016) analyzed the profile of the RCN among researchers who published on the main oilseeds involved in biodiesel production, from the co-authorship relationships present in selected papers. The authors chose 6 oilseeds and identified relationships among authors, countries, and institutions in publications on the oilseeds. Four countries participated in the publications on all the oilseeds studied: Brazil, India, China, and the USA. ▪ The experience of the Brazilian Network for Research in Reproductive and Perinatal Health and the positive impact on the Postgraduate Program in Obstetrics and Gynecology at the University of Campinas, Brazil, were presented by Cecatti *et al*. (2015). For them, reporting experiences with RCNs and the consequences for the Brazilian postgraduate system is a motivating opportunity. The authors believe in the potential of Brazilian scientists to create new RCNs, and highlight that this opportunity is vital for knowledge dissemination. ▪ Finally, Brunswig *et al*. (2013) presented the Dearfield Dream Project, a collaborative research initiative to conduct historical, cultural, archeological, and environmental studies at the site of the African-American colony of Dearfield, Colorado, USA, in the early 20th century. Due to the breadth of the project, an interdisciplinary RCN was set up to discover, preserve, and disseminate local knowledge and the economic, social, political, and environmental history of neighboring farms for better understanding and interpretation of their contributions to Colorado history. The data collected for research allowed the creation of network graphs that portrayed Dearfield's life through time.
Cluster 02	▪ Hou *et al*. (2020) combined SNA and econometric method to visualize and quantitatively evaluate international student mobility and RCNs. They concluded that international student mobility and scientific collaboration have a high degree of spatial correspondence. The importance of social capital was confirmed by social network theory, which holds that the location of nodes in a network largely determines the resources and opportunities they receive. In addition, linguistic proximity, colonial connection, and geographical distance were taken as control variables in the study, which was based on one of the simplest theories that human beings are carriers of knowledge and human migration is bound to produce the flow of knowledge. ▪ Considering the international and institutional diversity, Pandza, Wilkins, and Alfoldi (2011) studied the configurations of RCNs. According to them, the international diversity of collaborative research projects is influenced by two strategic objectives of the European Union (EU) research policy: subsidiarity and cohesion. In the context of arrangements that institutionalize the development of internationally and institutionally diverse research networks, the Framework Programmes (FPs), geographical and linguistic differences have contributed to the creation of smaller informal clusters within the formal collaborative projects, potentially affecting the general coherence of the project. The combination of international and institutional diversity inevitably influenced the effectiveness of research project collaboration within the EU's FPs.

#	Study highlights
Cluster 02	▪ Grba and Mestrovic (2018) described a set of measures and network algorithms chosen from the standard methodology of complex networks, suitable for researching RCNs. The analysis of collaborative networks provided an insight into the quality of relationships among network participants, making it possible to identify key leaders and participants, domains of interest, closely related communities, and future relationships. It also allowed studying the sharing of knowledge among network participants, in addition to identifying the flow of knowledge, an aspect considered important because it can provide information based on which it is possible to predict future steps and actions in a collaboration. ▪ In order to detect problems in the knowledge flow within research groups, with the help of a quantitative description, measuring the knowledge network, Lei and Xin (2011) applied SNA. In their study, knowledge sharing and knowledge flows of groups became a very important factor that affected the development of groups. The authors suggested improvements in the structure of the network and management strategies to improve the ability to share knowledge in the RCN. ▪ Kang and Munoz (2016) proposed an approach based on Markov chain Monte Carlo technique combined with Dynamic Network Analysis (DNA) to model a social network and understand how different knowledge dissemination strategies can be used in an RCN. The model presented is supported by dynamic rules to approximate the agents' behavior and the knowledge transfer parameters. These rules, which govern these parameters, have been organized into four matrix structures that are updated at each time step. The method was demonstrated through a case study using a multidisciplinary RCN in obesity. ▪ Yue *et al.* (2019) constructed a knowledge diffusion model of differential dynamics in scientific collaboration of non-uniform networks and conducted an empirical analysis on the model. After building the model, the authors discussed the relationship between the distribution of degrees and the evolution of knowledge diffusion to reveal the dynamic mechanics of knowledge diffusion in RCNs. The results showed that the evolution of the state of research entities in the knowledge diffusion process is affected not only by the evolution states of adjacent research entities with which they have certain collaborative relationships, but also by the structural attributes and distribution of degrees of the RCNs. ▪ Hackney, Desouza, and Irani (2008) presented insights about the dynamics of competitive knowledge networks. The authors considered complex and dynamic arrangements for potential and actual knowledge sharing in interorganizational networks. The authors presented results of empirical analyses of the experiences of automobile distributors, in a large US city, and an RCN. The study proposed a framework identifying the factors needed to initially build the network and then sustain it over time, considering social and political mechanisms in an approach to comprehensive business benefits. ▪ Considering that resilience is the ability of an RCN to maintain its effectiveness and knowledge flow in the event of any attack or disruption against the network, Liu *et al.* (2019) investigated an effective measurement index of network resilience and tried to accurately predict resilience thresholds in advance. According to the authors, the findings could help design optimal principles for dealing with disruptions or intervention strategies to prevent resilience loss from occurring in an RCN.

#	Study highlights
Cluster 02	▪ Zhao *et al*. (2021) analyzed the topology of an RCN and the heterogeneity of nodes. They presented a central node evaluation method, a community detection algorithm, and an improved visual layout algorithm to display the community structure of the RCN from many aspects. The experimental results showed that the proposed method can show more clearly the internal structure of the scientific research collaboration community ▪ Finally, the potential of social media for educational collaboration among education stakeholders was identified by Hina, Dominic, and Ratnam (2016). They also highlighted the crucial threats and risks associated with using this pattern of online collaboration. Thus, the authors recommended maintaining vigilant handling of potential cybercrime and adopting best practices for the safe and protected use of social media for the use of collaborative platforms in the educational context.
Clusters 03 and 04	▪ Ferreira *et al*. (2020) carried out a bibliometric and documentary analysis of the production of the journal *Ciência & Saúde Coletiva* (C&SC) in order to understand how oral health core appears in publications and how it could have contributed to the population's knowledge about health and diseases, specific public policies, education, and management of oral health services in the Brazilian Unified Health System. Also analyzing the co-authorship network, based on the authors of the publications and their institutions, C&SC proved to be a powerful instrument for the dissemination of scientific production, enabling the exchange of information and facilitating the integration between researchers and providing a path for its consolidation. ▪ Kumar and Jan (2014) applied SNA with the aim of calculating and analyzing the topological properties of the co-authorship network formed among earth scientists in India. The study detected a dense giant component that covered 73% of the network with a density of 0.0017 and an aggregation coefficient of 0.631, suggesting a high level of knowledge diffusion and a fast flow of information and creativity in the analyzed network. ▪ Finally, a bibliometric study about the RCNs among the professors of the Postgraduate Program in Epidemiology at the Federal University of Pelotas, Brazil, was presented by Maia and Caregnato (2008). The characteristics of collaboration were studied through the co-authorship of articles published in journals. According to these authors, shared work saves time and financial and material resources, contributing to the recognition of the researcher capable of forming good, efficient, and productive work teams.

Source: Elaborated by the authors.

4.3 PERSPECTIVES AND TRENDS

Highlighting some selected environments, within Table 5, this section analyzes how knowledge sharing occurs in the RCN context and discusses perspectives and trends in current environments.

Table 5 - Knowledge sharing through research collaborative networks

#	Perspectives and Trends
Scientific dissemination	▪ The need to innovate added to scientific development has established RCNs that cross geographical boundaries in knowledge sharing and dissemination. Once established, they contribute to the knowledge dissemination and a strong research framework (Cecatti *et al.*, 2015; Andrade, Guimarães & Galvão, 2016). According to Zhao *et al.* (2021), with the increasing complexity of scientific research, it has gradually turned to a collaborative approach, which can promote knowledge sharing, resource sharing, and improve the efficiency of scientific research. ▪ The effective dissemination of knowledge is essential to promote the adoption of new concepts and tools. According to Kang and Munoz (2016), the main objective of knowledge created at a given time is to reach a given space where knowledge is needed at the time it is needed. Starting from the premise that flow is synonymous with movement, whose dynamics consist in the sharing of resources between a sender and a receiver, according to Inomata (2017), the knowledge flow is based on experience and the information flow is based on data that have meaning, that is, knowledge made explicit and recorded in systematized language. Selected works highlight the importance of the flow of knowledge (Lei & Xin, 2011; Pandza, Wilkins & Alfoldi, 2011; Grba & Mestrovic, 2018; Hou *et al.*, 2020). ▪ In accordance with Hou *et al*. (2020), human migration is a channel for knowledge flows, exchanges, and collaboration that generate innovation. RCNs facilitate the knowledge flow on the one hand and, on the other hand, they increase the knowledge combination and also the productivity of the research team (Zamiri *et al*., 2019). The delineation of a model about the tangible knowledge existing in the organization, in order to contemplate the flow of explicit knowledge is necessary to better support KM. In this perspective, according to Santa Anna (2017), the flow of explicit knowledge is highlighted, which has been evidenced in the scope of knowledge organization in information units, in order to facilitate the work of treatment, organization, and storage of knowledge assets. ▪ In a social context, it is necessary for two agents to communicate in order to disseminate knowledge from an agent to the other. This communication process can be conducted through different communication channels and mechanisms, from face-to-face meetings to social media interactions (Kang & Munoz, 2016), which can assist organizations by reducing barriers in knowledge production and sharing activities, and even reaching a larger portion of society. According to Ross-Hellauer *et al*. (2020), among researchers, besides traditional modes, social media has become the most widely used digital dissemination channel. ▪ Finally, research dissemination should be treated as a planned process that involves consideration of target audiences, consideration of the environments in which research results are to be received, and communication and interaction with broader audiences in ways that facilitate acceptance and understanding of the research. According to Ross-Hellauer *et al*. (2020), innovative dissemination goes beyond traditional academic publications to achieve wider acceptance and understanding of research. In this context, the widespread use of digital resources is envisaged to support and enhance research activities, and to amplify the access, visibility, and social impact of scientific productions.

#	Perspectives and Trends
Social network analysis	▪ The topological structure of the RCN directly affects the network knowledge flow effect and the carrying out of scientific research (Liu et al., 2019). RCNs can be weighted and/or directed. Weights can denote the number of interactions, projects, or publications. Directions can denote the direction of communication, institutional exchange, or knowledge sharing (Grba & Mestrovic, 2018). Widely applied in the selected papers (Maia & Caregnato, 2008; Lei & Xin, 2011; Kumar & Jan, 2014; Andrade, Guimarães & Galvão, 2016; Kang & Munoz, 2016; Hina, Dominic & Ratnam, 2016; Haddad, Mena-Chalco & Sidone, 2017; Grba & Mestrovic, 2018; Hou et al., 2020; Zhao et al., 2021), SNA works on these aspects. After all, turning research data into useful information and useful information into knowledge is a critical factor for success (Lima & Bastos, 2019). ▪ The first attempts to analyze collaborative networks focused on networks based on scientific publications (Grba & Mestrovic, 2018). In this context, a special case of collaborative networks are co-authorship networks, which continue to be the most commonly analyzed networks in the last decade (Grba & Mestrovic, 2018). Co-authorship is one of the most significant, tangible, and verifiable indicators of collaboration among researchers. In recent years, increasing attention has been paid to the concept of knowledge dissemination within social networks. ▪ RCNs are a special case of social networks, in which nodes represent individuals who collaborate on particular projects or scientific publications (Newman, 2001a). Newman (2001b) was one of the first to intensively study the structure of RCNs in terms of SNA. According to Brandão et al. (2013), co-authorship social networks are formed by researchers and their connections are given by collaborations on publications. The use of SNA can lead to the identification of the groups that are actively researching in a given knowledge area and the influence of different groups within the research community (Newman, 2001b). ▪ Knowledge networks are highlighted in the works of Hackney, Desouza, and Irani (2008) and Lei and Xin (2011). According to Ma et al. (2017), through a knowledge network, members of the research community are able to add publications and datasets that may be useful to others, find colleagues working on similar projects, discover methods and tools that can be used to analyze data in new ways, and create more and better research collaborations. These networks also promote collaboration among participants in scientific communities, improve the openness and replicability of research related to the target areas, facilitate accreditation to resource contributors, and stimulate new ideas and discoveries in studies related to the target areas. ▪ Finally, aspects of the dynamics of RCNs are highlighted in the works of Kang and Munoz (2016) and Yue et al. (2019). According to Kang and Munoz (2016), one of the main advantages of Dynamic Network Analysis over traditional SNA is that DNA incorporates the dynamic nature of social networks, supporting network modeling under a more comprehensive framework that allows the prediction of important features such as knowledge diffusion. According to them, the results presented in their study can be used at a managerial level to better use communication and promotional resources when disseminating knowledge within a network.

Source: Elaborated by the authors.

5 CONCLUSION

Research is one of the main indicators of quality of the services provided by Higher Education Institutions. The digital assets produced by Research Collaborative Networks need to be disseminated in order to promote their effective transformation for the benefit of social, cultural, and economic development. The omnipresence of the international aspect in the formation and dissemination of knowledge is a relevant and already established fact in higher education, and it is possible to affirm that the Research Collaborative Networks directly contribute to the quality of Higher Education Institutions. Recent studies point to internationalization and digital transformation among the most important trends in higher education.

Knowledge Societies are characterized by the proliferation of knowledge-intensive communities specializing in the production and sharing of knowledge. Researchers need to share their research results with wider audiences, on a larger scale. The dissemination of science and technology is fundamental for the formation of societies that are informed about the implications of scientific knowledge in the most diverse spheres of everyday life.

Scientific development has enabled countless benefits for our daily lives and is directly related to changes in society's way of acting and thinking. Scientific dissemination, through social media, is one of the most promising ways for information and knowledge to reach audiences massively and quickly, as it is capable of boosting the democratization of knowledge and access to information, accelerating the dissemination of science, and promoting interactions between researchers and society.

However, scientific and technological development has also brought destructive interferences, such as the widespread dissemination of disinformation and, consequently, the increase in violence and intolerance. In this scenario, the relevance of learning how to communicate science becomes clear, not only for the traditional reasons of democratization of knowledge, but because people's survival may depend on a more attractive and effective dissemination. It is necessary to share socially relevant scientific knowledge, and thus contribute to the common good. Higher Education Institutions and Research Collaborative Networks can contribute substantially to this end.

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REFERENCES

*Andrade, I. L., Guimarães, C. M. M. & Galvão, V. (2016). Rede de colaboração científica sobre oleaginosas envolvidas na produção do biodiesel. *Perspectivas em Ciência da Informação*, 21, 207–224. doi.org/10.1590/1981-5344/2605

Brandão, M. A., Moro, M. M., Lopes, G. R., & Oliveira, J. P. M. (2013). Using link semantics to recommend collaborations in academic social networks. WWW 2013 Companion - Proceedings of the 22nd International Conference on World Wide Web, 833–840. doi.org/10.1145/2487788.2488058

*Brunswig, R., Junne, G., Bowser, G., Renfrew, E., Dickmann, E., Purnell, A., & Brown, M. (2013). Dearfield dream project: Developing an interdisciplinary historical/cultural research network. *Social Sciences*, 2(3), 168–179. doi.org/10.3390/socsci2030168

Camarinha-Matos, L., & Afsarmanesh, H. (2008). On reference models for collaborative networked organizations. *International Journal of Production Research*, 46, 2453–2469. doi.org/10.1080/00207540701737666

*Cecatti, J. G., Silveira, C., Souza, R. T., Fernandes, K. G., & Surita, F. G. (2015). Experience with the Brazilian network for studies in reproductive and perinatal health: The power of collaboration in postgraduate programs. *Revista do Colegio Brasileiro de Cirurgioes*, 42, 89–93. doi.org/10.1590/0100-69912015S01027

Dalkir, K. (2017). *Knowledge management in theory and practice*. (3th ed.). The MIT Press.

*Ferreira, E. F., Ferreira, R. C., Botazzo, C., Gomes, V. E., Rodrigues, L. G. & Vargas, A. M. D. (2020). A ciência da saúde coletiva por escrito: contribuição para estudos em saúde bucal coletiva. *Ciência & Saúde Coletiva*, 25, 4875–4886. doi.org/10.1590/1413-812320202512.28362020

Firestone, J. M., & McElroy, M. W. (2005). Doing knowledge management. *The Learning Organization*, 12(2), 189–212. doi.org/10.1108/09696470510583557

Garrard, J. (2016). *Health Sciences Literature Review Made Easy: The Matrix Method*. (5th ed.). Jones & Bartlett Learning.

*Grba, B., & Mestrovic, A. (2018). Tracking the evolution of scientific collaboration networks. 2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics, MIPRO 2018 - Proceedings (pp. 503–508). Institute of Electrical and Electronics Engineers Inc. doi.org/10.23919/MIPRO.2018.8400096

*Hackney, R., Desouza, K. C., & Irani, Z. (2008). Constructing and sustaining competitive interorganizational knowledge networks: An analysis of managerial Web-based facilitation. *Information Systems Management*, 25(4), 356–363. doi.org/10.1080/10580530802384654

*Haddad, E. A., Mena-Chalco, J. P., & Sidone, O. J. G. (2017). Scholarly Collaboration in Regional Science in Developing Countries: The Case of the Brazilian REAL Network. *International Regional Science Review*, 40(5), 500–529. doi.org/10.1177/0160017615614898

*Hina, S., Dominic, P. D. D., & Ratnam, K. A. (2016). A Relational Study of Critical Threats and Risks Affecting the Potential Usage of Collaborative Pattern. *Global Journal of Flexible Systems Management*, 17(4), 373–388. doi.org/10.1007/s40171-016-0133-5

*Hou, C., Fan, P., Du, D., Gui, Q., & Duan, D. (2020). Does international student mobility foster scientific collaboration? Evidence from a network analysis. *Compare-A Journal of Comparative and International Education*. doi.org/10.1080/03057925.2020.1765316

Inomata, D. O. (2017). Redes colaborativas em ambientes de inovação: uma análise dos fluxos de informação. Tese de doutorado, Universidade Federal de Santa Catarina, Centro de Educação, Programa Pós-Graduação em Ciência da Informação, Florianópolis, SC, Brazil.

*Kang, H., & Munoz, D. (2016). A Dynamic Network Analysis approach for evaluating knowledge dissemination in a multi-disciplinary collaboration network in obesity research. Proceedings - Winter Simulation Conference, 2016-Febru, 1319–1330. doi.org/10.1109/WSC.2015.7408256

*Kumar, S., & Jan, J. M. (2014). Relationship between authors' structural position in the collaboration network and research productivity: Case of Indian earth scientists. *Program Electronic Library and Information Systems*, 48(4), 355–369. doi.org/10.1108/PROG-01-2013-0002

*Lei, G., & Xin, G. Q. (2011). Social network analysis on knowledge sharing of scientific groups. LISS 2011 - Proceedings of the 1st International Conference on Logistics, Informatics and Service Science, 3, 71–76.

Leite, D., & Pinho, I. (2016). *Evaluating collaboration networks in higher education research: Drivers of excellence*. Springer International Publishing.

Lima, C., & Bastos, R. (2019). Knowledge Creation supported by Data Governance. Proceedings of the 9th International Conference on Knowledge and Innovation, CiKi 2019. Porto Alegre, Brazil.

Lima, C., Bastos, R., & Bastos, L. (2020). The Information Quality impact on Learning Platforms. *RENOTE*, 18, 59–68. doi.org/10.22456/1679-1916.110204

*Liu, D., Wu, Z., Guo, Q., & Shi, Y. (2019). Resilience and Its Thresholds of Scientific Collaboration Network. *IEEE Access*, 7, 69339–69350. doi.org/10.1109/ACCESS.2019.2911552

Lobiondo-Wood, G., & Haber, J. (2017). *Nursing research: methods and critical appraisal for evidence-based practice*. (9th ed.). Mosby.

Ma, X., West, P., Zednik, S., Erickson, J., Eleish, A., Chen, Y., Wang, H., Zhong, H., & Fox, P. (2017). Weaving a knowledge network for deep carbon science. *Frontiers in Earth Science*, 5. doi.org/10.3389/feart.2017.00036

*Maia, M. F. S. & Caregnato, S. E. (2008). Co-autoria como indicador de redes de colaboração científica. *Perspectivas em Ciência da Informação*, 13, 18–31.

Newman, M. E. J. (2001a). Scientific collaboration networks. I. Network construction and fundamental results. *Phys. Rev*. E, 64(1), 16131. doi.org/10.1103/PhysRevE.64.016131

Newman, M. E. J. (2001b). The structure of scientific collaboration networks. Proceedings of the National Academy of Sciences of the United States of America, 98, 404–409. doi.org/10.1073/pnas.021544898

Orange. (2021). Data Mining Fruitful and Fun: Open source machine learning and data visualization. Version 3.28. Retrieved on May 20, 2021 from orangedatamining.com

*Pandza, K., Wilkins, T. A., & Alfoldi, E. A. (2011). Collaborative diversity in a nanotechnology innovation system: Evidence from the EU Framework Programme. *Technovation*, 31(9), 476–489. doi.org/10.1016/j.technovation.2011.05.003

Ross-Hellauer, T., Tennant, J. P., Banelytė, V., Gorogh, E., Luzi, D., Kraker, P., Pisacane, L., Ruggieri, R., Sifacaki, E., & Vignoli, M. (2020). Ten simple rules for innovative dissemination of research. *PLOS Computational Biology*, 16(4), 1–12. doi.org/10.1371/journal.pcbi.1007704

Santa Anna, J. (2017). Modelo de fluxo do conhecimento nas organizações: proposta de mapeamento para construção e gestão de portal de periódico. *Revista Conhecimento em Ação*, v. 2, p. 73-92, 2, 73-92.

Souza, R. K. (2019). Compartilhamento de Conhecimento por Grupos de Pesquisa: mídias, utilização e potencialidades. Dissertação de mestrado, Universidade Federal de Santa Catarina, Centro Tecnológico, Programa de Pós-Graduação em Engenharia e Gestão do Conhecimento, Florianópolis, SC, Brazil.

Vacca, R., Mccarty, C., Conlon, M., & Nelson, D. R. (2015). Designing a CTSA-Based Social Network Intervention to Foster Cross-Disciplinary Team Science. *Clinical and Translational Science*, 8(4), 281–289. doi.org/10.1111/cts.12267

*Yue, Z., Xu, H., Yuan, G., & Pang, H. (2019). Modeling study of knowledge diffusion in scientific collaboration networks based on differential dynamics: A case study in graphene field. *Physica A: Statistical Mechanics and Its Applications*, 524, 375–391. doi.org/10.1016/j.physa.2019.04.201

Zamiri, M., Marcelino-Jesus, E., Calado, J., Sarraipa, J., & Goncalves, R. J. (2019). Knowledge Management in Research Collaboration Networks. In L. M. Zheng F. Chu F. (Ed.), Proceedings of the 2019 International Conference on Industrial Engineering and Systems Management, IESM 2019. Institute of Electrical and Electronics Engineers Inc. doi.org/10.1109/IESM45758.2019.8948162

*Zhao, W., Luo, J., Fan, T., Ren, Y., & Xia, Y. (2021). Analyzing and visualizing scientific research collaboration network with core node evaluation and community detection based on network embedding. *Pattern Recognition Letters*, 144, 54–60. doi.org/10.1016/j.patrec.2021.01.007