COLLABORATIVE NETWORKS, HISTORICAL-CONCEPTUAL REVIEW AND THE “WE” TEACHERS IN BRAZIL’S STRICT SENSU

REDES COLABORATIVAS, REVISÃO HISTÓRICO CONCEITUAL E OS PROFESSORES “NÓS” NO STRICTO SENSU DO BRASIL

REDES COLABORATIVAS, REVISIÓN HISTÓRICO-CONCEPTUAL Y EL “NOSOTROS” DOCENTES EN EL SENTIDO ESTRICTO DE BRASIL

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ABSTRACT
This article presents a historical and conceptual review of collaborative networks in science, focusing on the role of teachers, researchers, and advisors—who serve as the "nodes" of academic intellectual production that have driven intellectual and scientific output in graduate education (stricto sensu) in Brazil over the past 20 years. The study is based on bibliographic and documentary research with a qualitative approach, and data are analyzed using the Discursive Textual Analysis (DTA) technique. Collaboration in science emerged from the efforts of artisans and apprentices to share their knowledge and creations. Later, it became a way to draw the attention of scientists and humanists to a routine yet often overlooked aspect of scientific production: collaboration as both a technique and a humanistic dimension of knowledge creation. Scientific networks are sustained by the strength of educators [nodes] who challenge their students [edges] to explore this theme, fostering the development of collective competencies to solve problems across various fields of knowledge.
KEYWORDS: collaborative networks; stricto sensu in Brazil; “we” teachers; scientific research; intellectual production.

RESUMO
Apresenta-se uma revisão histórico-conceitual sobre redes colaborativas na ciência, e na atualidade, e os professores/pesquisadores/orientadores, que são os “nós” da produção intelectual acadêmica que fomentam a produção intelectual e científica no stricto sensu nos últimos 20 anos, no Brasil. Trata-se de uma pesquisa bibliográfica e documental com abordagem qualitativa e análise dos dados pela técnica de análise textual discursiva (ATD). A colaboração na ciência nasceu prodigiosa pela intenção dos artesãos e aprendizes de socializar seus conhecimentos e suas produções. E mais tarde, para chamar a atenção de cientistas e humanistas à uma atividade corriqueira, porém invisibilizada, da produção científicas: a colaboração como técnica e aspecto humanístico da produção de conhecimentos. A Ciência em redes perpetua-se pela pujança de professores [nós] que desafiam seus discentes [as arestas], a investigarem o tema para o desenvolvimento de competências coletivas para a resolução de problemas nas mais diversas áreas do conhecimento.
PALAVRAS-CHAVE: redes colaborativas; *stricto sensu* no Brasil; professores “nós”; pesquisa científica; produção intelectual.

RESUMEN
Se presenta una revisión histórico-conceptual sobre las redes colaborativas en la ciencia, y en la actualidad, y los docentes/investigadores/orientadores, quienes son los “nodos” de producción intelectual académica que fomentan la producción intelectual y científica en sentido estricto en los últimos 20 años, en Brasil. Se trata de una investigación bibliográfica y documental con enfoque cualitativo y análisis de datos mediante la técnica del análisis textual discursivo (ATD). La colaboración en la ciencia nació prodigiosamente debido a la intención de artesanos y aprendices de socializar sus conocimientos y producciones. Y más tarde, llamar la atención de científicos y humanistas sobre una actividad común, pero invisible, en la producción científica: la colaboración como técnica y aspecto humanístico de la producción de conocimiento. La ciencia en redes se perpetúa por la fuerza de los docentes [nosotros] que desafían a sus estudiantes [los bordes], a investigar el tema para desarrollar habilidades colectivas para la resolución de problemas en las más diversas áreas del conocimiento.

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PALABRAS CLAVE: redes colaborativas; stricto sensu en Brasil; nosotros docentes; investigación científica; producción intelectual.

1 PRESENTATION

This work approaches the dynamics of the production of knowledge and knowledge in collaborative networks in science. It is a theme that arouses the interest of researchers all over the world, being an action present in stricto sensu teaching institutions in the world, and also in Brazil, with extensive production in the last 20 years.

The bibliographical and historical-conceptual review pointed out that collaborative networks in science were born in the middle ages when artisans and apprentices got together to share inventions and socialize knowledge among their peers, these meetings Derek Solla Price (1963) identified as Invisible Colleges. These encounters continually strengthened and gradually became a permanent field of mutation and reconstruction. Currently, technological evolution and the internet are facilitators of collaborative scientific networks that have expanded, taken on new forms and become an intrinsic part of globalized scientific production.

In the current context of globalization, and of new information and communication technologies, it is observed that the researches that arise from scientific collaboration networks are distributed among the most diversified areas of knowledge in postgraduate programs whose product [articles, theses, dissertations] provide essential data for the measurement/valuation of researchers, graduate programs (PPGs) and universities around the world. In addition to "situating the production of a country in relation to the world, an institution in relation to its country and even scientists in relation to their own communities" through the use of bibliometrics (Macias-Chapula, 1998, p. 134).

Within the scope of stricto sensu postgraduate courses are researchers who, in solidarity, dedicate themselves to the continuous production of knowledge through scientific investigation. They are the "nodes" [teachers/researchers] who together with their students [edges] promote unprecedented and/or expanded collaborative networks in science.

It is known that research on science, man and technology arouses interest over centuries and generations. Price (1976, p. 20) answering to his own question about "what is the origin of the peculiarly scientific basis of our generation?" describes that

> The current generation can stand on the shoulders of giants and examine, in great detail, the history of science in China, the complexities of Babylonian mathematics and astronomy, the manipulations of Mayan calendar conservatives, and the scientific hesitations of the ancient Egyptians. […] we have today, a highly

> scientific technology: the repercussions of science shape our daily lives, shape the destiny of nations and the philosophical implication of the Scientific Revolution […] (Price, 1976, p. 20).

With this premise, this research sought, through a literature review, to identify theories about collaborative networks, to know and systematize what are the different concepts and applications to the set of terms used to denominate collaboration and/or cooperation actions for the production of new scientific knowledge. In addition to analyzing and illustrating these relationships, based on the concept that "[...] scientific research is an eminently social activity and, consequently, Science is a form of public knowledge, according as a scientific fact - the knowledge generated by Science - is recognized by the scientific community after an extensive process of communication between peers" (Ziman, 1979, p. 24), whether formal or informal.

Collaborative networks in science arise spontaneously and/or intentionally, and are records of solidarity between researchers, and the urgency of operationalizing investigations and discoveries to generate new knowledge that address the problems that affect society. These networks are known as social relationships in science, in scientific collaboration that has aroused worldwide interest "since Babylon[3]" considered "the embryo of modern science present since the 16th century" (Price, 1976, p. 21) emerged with the concept of colleges invisible through Price's (1976) essays on formal collaboration, and/or Crane's (1972) informal ones. These pioneers affirm that "networks" generate science production that is not just research and investigation activities. They are social relations recognized as collaborative networks in science, a complex human social and interactive process that can happen under different approaches, contexts, motives and formats.

For this reason, to understand the generation of scientific knowledge production, on scientific collaborative networks, it is substantial "to note how scientists behave, relate, organize themselves, and how they transmit information to each other" (Vanz & Stumpf, 2010, p. 1). Mendenhall, et al. (1982, p. 7, our translation) answering about why to worry about investigating scientific publications/productions, in this work are theses and dissertations, he states that "in the first place, research on the phenomenon tells us more about the dynamics of groups, so this phenomenon deserves study simply because it is a social phenomenon in itself" and concludes: "secondly, by studying these and other trends in the research process we can see where we have been and where we are going, and decide whether

[3] The reference "from Babylon" became known due to the publication of the book: "Science from Babylon" by Derek de Solla Price (1976) with the theme "The history of science and the humanistic aspects of Science".

we want to go there ”.

These observations take to the methodology of the second part described in this work: to investigate what are the "nodes" of scientific production in the last 20 years in the Brazilian stricto sensu, on the topic of collaborative networks. For this, this investigation used a search in the Capes catalog of theses and dissertations with the descriptor “collaborative networks” without any refinement, on October 12, 2021. One hundred and sixty works were retrieved.

This work is divided in two parts. The bibliographic review of works, books and articles made it possible to rescue authors and fundamental concepts about “collaborative networks” and express this relationship in science. The documentary research of Brazilian theses and dissertations over the last 20 years identified the universities and research professors that encourage the development of original scientific research, promoting the continuity, expansion and improvement of the theme, and their applicability in the research context.

2 UNDERSTANDINGS ABOUT COLLABORATIVE NETWORKS IN SCIENCE

The definition of the word 'network' comes from the Latin 'retis', which refers to the intertwining of threads that, when connected regularly, form a kind of fabric and the design of a web. Due to the various conceptions of the term network, the expression has become common, being used in various institutional and academic environments, in the latter, in the numerous areas of scientific knowledge, and in the production of goods and services from the most basic to the most technological.

Adjacent to this, it is necessary to consider the social networks that connect people with common interests across the planet, according to the definition of Hanneman (2001) these social networks are people or groups, researcher, institution, organization and the collectivity [actors] and their actions that occur through connections through channels such as the internet. It is observed that technology, communication and the internet do not promote, rather, they favor these ties of approximation between scientists and researchers, who approach forming networks in science.

We will follow the definition of 'network' proposed by Castells (1999) which claims to be a set of interconnected 'nodes', considering that they are people, groups and institutions that relate to form a fabric, respecting the same relationship criteria with common objectives, these connections between 'nodes' are recognized as edges. Castells (2000) characterizes the social network structure as a collaborative and open system, highly dynamic, susceptible to

innovation, without this affecting its balance. It is added that the origin of the word “collaboration” refers us to labor, working together, in cooperation with the other.

For these networks, events are important spaces for meeting and sharing knowledge. Among these, the conferences promoted by the "Global Interdisciplinary Research Network" - COLLNET[4], to Webometrics, Informetrics and Scientometrics (WIS) stand out, with the title "Global interdisciplinary research network for the study of all aspects of collaboration in science and technology". Which currently enable discussions on topics related to collaboration networks in science worldwide.

Such events and conferences are consecrated spaces for problematizing research carried out in the strict sense, because they encourage socialization, contextualization and make it possible to update the debate on collaborative networks. They reaffirm historical concepts, expanding the conceptualization and understanding of the term and its concepts, which come from a long time ago, as observed in the next sub-item.

2.1 SCIENCE AS A SOCIAL PROCESS

The advancement of science depends especially on interaction and collaboration among scientists. Likewise, their work depends, to a large extent, on those who came before them and built the foundations of science and knowledge.

Merton (1945, p. 193) wrote in the work “Essays on the sociology of knowledge” the statement “the communal character of science is reflected in scientists' recognition of their dependence on a cultural heritage in relation to which there are no differential rights”. He quotes Isaac Newton's phrase to reaffirm his conviction and express a sense of indebtedness to the heritage left by predecessors, as well as recognition of the quality knowledge acquired through cumulative cooperation in favor of scientific achievement, "if I could see further, it was by standing on the shoulders of giants” (Merton, 1945, p. 193). He states that wisdom is not only cumulatively appropriate, "it also depends on the understanding that scientific advancement involves the collaboration of present and past generations". And in these windings, the author infers that humility is necessary for scientific geniuses and mentions sociology as one of the tools indicated for science in understanding social reality and its consequences.

> In its purpose, science is communism. In science, men consciously learned to

[4] It is the leading international conference in the field of scientometrics in the following countries: Germany, India, Australia, China, Sweden, France, Turkey, Estonia, United Kingdom and Macau. Source: https://www.collnet.de/.

> subordinate themselves to a common purpose without losing the individuality of their achievements. Each one knows that his work depends on his predecessors and colleagues and that its fruits can only be achieved through the work of his successors. In science, men collaborate not because they are forced by superior authority or because they follow blindly to be the chosen leader, but because they realize that only in this voluntary collaboration can each one find his goal (Bernal, 1939, p. 415-416, our translation).

Bernal (1939), communist and Marxist scientist, devoted himself to describing the importance of solidarity among scientists, and to reaffirm the function of science for the development of society. According to Netto (2016, p. 1) Bernal's[5] ideas about the social function of science are a legacy that still represent a major challenge for researchers and politicians. Netto (2016) also states that Bernal inaugurated an era of science focused on the needs of society, the commitment of scientists should be with a "science dedicated to peace, well-being and benefits for humanity" this expression of the social responsibility of scientists, described in the book The Social Function of Science (The Social Function of Science) would be primarily oriented towards overcoming poverty and establishing social well-being (Bernal, 1939 apud Netto, 2016, p. 1).

The Brazilian Macias-Chapula (1998, p. 136)[6] declares that "Science is a social process.

> The actions and behavior of scientists depend on the context" and in this integration [social process] science assumes three functionsscience needs to be considered as a broad social system, which one of the functions is to disseminate knowledge. The second function is to ensure the preservation of standards, and the third is to attribute credit to those whose works have contributed to the development of ideas in different fields (Macias-Chapula, 1998, p. 136).

In addition to these, other essays and concepts established the first conceptions of intellectual connections in science, using instruments that still guide research today, using publications and co-authorship: Boyle (1645) was the first to observe groups of researchers and to mention the term Invisible Faculty; Bernal (1939) on Science being an Eminently Social Activity; Smith (1958) and Beaver and Rosen (1966-1978) on Scientific Collaboration Studies; Ziman (1979) on the analysis of the Social Dimension of Science; and finally, the theory of Invisible Colleges on the Formal Collaboration between scientists by Price (1941 to 1985) and Informal by Crane (1972).

The first researchers that noted social relations in science, what we will call "Scientific

[5] Amoud Bernal's many works, the following stand out: What future awaits humanity? Rio de Janeiro (1967) (Science in History) – Science in History, Lisbon (1975-1978), and Social History of Science, Barcelona (1997).
[6] Paper presented at the Seminar on Evaluation of Scientific Production, held in São Paulo by the SciELO Project, March 4-6, 1998.

Collaborative Networks" used metrics (something that is measured) and applied their studies on the incidence of publications and on the co-authorship of articles and scientific works, making links between authors, co-authors, institutions and research sites, noting in particular the approximations, increases and declines of these publications, initially focused on bibliometrics and scientometrics[7] called scientometrics (WIS). These metric studies are the result of the unfolding of the sociology of science that is a branch of sociology and information science.

Researchers and sociologists of Science and the Social History of Science such as Garfield (1955) and Price (1976) found in bibliometrics the necessary method for understanding scientific activity as a social phenomenon social studies of science, a clearly interdisciplinary field that draws on technical and conceptual resources from different areas of knowledge to learn about the structure and organization of scientific[8] production in the face of social demands[9].

In this article, the relationship between bibliometrics and scientific communication processes is part of the analysis of the theme “Networks” using the theoretical construction of Invisible Colleges as a focal example. Based on the work of Price (1963-1965-1966), Hagstrom (1965) and Crane (1972) the Invisible Colleges or the invisible college, which has the same meaning, was widely accepted as a description of certain social relations in science. Thus, the term “invisible college/s” will replace the various uses of similar terms with the same understanding, including the term Invisible Colleges conceptualized by the authors already highlighted.

3 SCIENTIFIC COLLABORATION: THEORETICAL-CONCEPTUAL REVIEW

The term invisible faculty was first used by Robert Boyle in 1645, one of the progenitors of the Royal Society[10], groups of British natural philosophers who meet to acquire knowledge through experimental investigation.

These relationships in science take us back to historicity and to Price's remarkable finding (1976, p. 98-99). The author argues that the first group of practitioners of science to

[7] The term was coined in 1966 by Soviet chemist Vasily Nalimov. However, one of the main thinkers to develop the study of scientometrics was the British Derek de Solla Price.
[8] Focused on the analysis of social relations and expressions through the production of scientific knowledge and its publications.
[9] Closely linked to the disciplines of mathematics, statistics and informatics, it seeks to measure the quantitative studies of science and technology.
[10] The Royal Society is an institution dedicated to the promotion of scientific knowledge founded on November 28, 1660 in London.

emerge were surveyors in England during the reign of Queen Elizabeth, they were required when it comes to the distribution of land, consequent to the dissolution of monasteries. As well as the first professors of arithmetic, navigation and manufacturers of magnetic compasses that benefited “when Queen Elizabeth decided to no depend of foreign powers for cannons and founded the Mines Royal and Battery Company”. Thus came the large-scale manufacture of astronomical instruments and other instruments as possible using the best raw material at the time, the bronze plate.

Following this modest beginning, “the growing need for an artisan workforce multiplied, and each master prepared three or four apprentices, who later became independent” Price (1976, p. 99). In 1650 these professionals and craftsmen, more than 100, gathered in dozens of independent establishments in central London in industrial activities appreciable at that time. Price (1976, p. 99) states that “in fact, the very emergence of the Royal Society can be directly attributed to “those professionals” who, in order to socialize their inventions and knowledge, initially met informally, as in a club, called “Invisible Colleges”, in the facilities, workshops, factories and taverns (known today as cafés) also used, at the time, as everyone's postal address.

The expression "Invisible Colleges" was appropriated by professor and researcher Derek de Solla Price[11] and published in his book Little Science, Big Science Babylon in 1961, where he described Invisible Colleges within the context of "sciences" and suggested that this term, loaded with meanings, and representative relationships in science, might well be the subject of an interesting sociological study. Price (1963) expanded on this idea in his article Little Science, Big Science, in which a chapter is devoted to Invisible Colleges and the Affluent Scientific Commuter. In this work, the author was the first to use scientometrics to qualify and quantify science phenomena through the publication of articles and journals[12], using the study of bibliographic references and the Science Citation Index (SCI) database[13].

[11] Derek de Solla Price was a physicist, historian of science and information scientist, and is known as the father of scientometrics.

[12] It was Smith in 1958 who did the first metric experiment and provided evidence of author productions in analysis of multiple authorship in science.

[13] Faced with difficulties in assessing the relevance of scientific literature after World War II, and inspired by Shepard's Citations (an index used in the legal field), Eugene Garfield proposes the creation of the Science Citation Index (SCI). Garfield died in 2017 in Pennsylvania at the age of 91, he was a librarian, sociologist and computer scientist, responsible for many innovative bibliographic products. Among them, he developed in 1955 a comprehensive index of citations showing the spread of scientific thought presented in the journal Science, with the proposal of a database that would facilitate the use of cited articles to find other articles, noting that there is a connection between the citing article and the article being cited. Thus, the ICS established a new image of scientific literature, in the same way that a telephone directory creates an image of the inhabitants of a city. This database was explored by Price (1961 and 1963) and became a tool for verifying productivism in science through analysis of citation indexing from the Science Citation Index (SCI), a citation index that allows a

About Price's imperious contribution to scientific production, with his essays and metric studies for science, with concepts established by him that still largely guide investigative work, Fernández-Cano et al. (2004, p. 301) state that Derek John de Solla Price[14], "undoubtedly represents a giant with big shoulders where we, the common people, seek support".

Currently, Vanz and Stumpf (2010, p. 43) state that the concept of collaboration in science "becomes even more complex, and that the full understanding of its meaning is far from being achieved". Mainly because of the spread of the term and the broad scientific language to quantify and understand the relations of scientific production in science, in the form of networks.

In addition to the terms and concepts, this study highlights the importance of "key individuals" in the dissemination of information in a scientific area, described as – individuals/researchers [nodes] they are the elite members of the Invisible Colleges, composing- if from the edges, lines that unite two "nodes", thus forming a large collaborative web that corresponds to a graph[15]. These networks, composed of the most productive authors, are an important aspect of the social organization of a scientific area, because they tend to integrate separate groups of collaborators and promote the development of the areas of knowledge. It is necessary to consider here the intellectual production that appears in the stricto sensu.

About communication in science through edges joined by "knots" that form networks/webs, the psychologist Milgram (1967, p. 60-67) published the "theory of the six degrees of separation"[16], and with that he defined a design for such, he proposed a curious thesis known as Small World (small world) in which a maximum of six links or bonds of friendship are enough for any two people to be connected. The term suggests that each node is

researcher to identify citations to an article, or search for articles by author, used, for example, in the Web of Science.

[14] Price's life, work and legacy were the subject of study by authors such as Braga (1974, Garfield (2008) and Hayashi et al, (2021), who outlined a historical overview of the author's representativeness in the fields of Social Studies of Science, such as the Sociology of Science, the History, Philosophy and Anthropology of Science, the field of Information Science with Scientific Communication, mathematics and statistics. It is noteworthy that Price has been to Brazil three times, once as a tourist and two for work. He made contributions to the creation of science policy at CNPQ: "after a period of research and lectures, I made a summary report on science policy in Brazil [...] and proposed the creation of a small policy unit science at CNPq (Price, 1978, p. 38).

[15] Graph theory differs from complex network theory; this emerged with the internet and information technology, mainly because complex networks are characterized by (i) the modeling of real networks; (ii) networks evolve, therefore they are not stable in terms of their structure; and (iii) are dynamic insofar as they can be simulated. See studies by Raquel da Cunha Recuero in: https://doi.org/10.30962/ec.28

[16] The theory of the six degrees of separation was created by Milgram through a series of experiments in which he asked a person to pass a letter to another, provided that other person was known. The goal was for the letter to reach a certain person, unknown to the first person, who lived in another city. According to Milgram, the average number of times the letter was passed was six - hence the six degrees of separation theory.

connected to the others and represents someone. The relationships between people can be seen as connections, or even lines (links-edges) between one node and another.

Retrospectively, the 50s and 60s marked the beginning of studies on scientific collaborations, from start with theoretical studies, essays and empirical tests that leveraged the professionalization of science.

In the 1970s, new knowledge about collaborative networks in science was generated. Storer's research (1970) showed what was intuitively assumed until then, that the degree of cooperation varies greatly between the different areas of knowledge, according to the cognitive and organizational characteristics and specificities of each one.

In 1971, Meadows and O'Connor published the statement that scientific collaboration is characterized by the set of co-signed works carried out in cooperation between two or more researchers, which allow for the identification of the researchers involved, their countries of origin and their institutions, which are usually universities and research centers private, facts that previous studies did not observe.

Crane's work Invisible Colleges (1972) innovates in studies by visualizing that invisible colleges are informal relationships and form informal communication networks with geographic dispersion.

The years that followed, between the 1980s and the 2000s, saw the spread of terms and concepts about collaborative networks. The expansion of technologies and access to the internet provided an opportunity for a flow of theorists who emerged with research on the term collaborative networks linked to the media world, cyberculture, the internet, social mobilizations for human rights and citizenship, in art and theater, in education in its various modalities, and many other spaces where there is human interaction in a network for the production of new knowledge.

In this new version of the uses of terms correlated to research, some researchers, sometimes as advisors, sometimes as researchers/authors of thesis or dissertation, sometimes as researchers in research groups linked to universities, which are the locus of this work, encourage formal production or informal and move the world of scientific publications and intellectual production.

Already in the 21st century stands out authors such as (Balestrin and Verschoore, 2008; Camarinha-Mattos and Afsaranesh, 1999, 2004, 2005, 2006, 2007, 2008; Castells, 1999, 2000; Fukuyama, 2000; LOSS, 2007; Vallejos, 2005, Guerrini, 2008, 2013) that address correlated and shared terms when referring to the theme “relationships in networks”: “such as coherence and connectivity, cooperation, interdependence, autonomy, trust,

interactivity, collaboration, shared goals and values, culture , communion, communication, association, articulation, norms and collective benefits" (Faccin, 2010, p. 31). These demonstrate the conceptual diversity when dealing with human networks in scientific collaboration in their most heterogeneous applications. These new terms are present in stricto sensu research, but specifically on interconnectivity, culturality and sociability tools.

4 METHODOLOGY

The search for the theses and dissertations repository at Capes, on October 12, 2021, using the descriptor "collaborative networks" as the search key, retrieved stricto sensu works dating from January 2001 to December 2020. of these 20 years, he formed a group with 160 recovered publications[17], 94 of which were dissertations and 66 theses.

The first categorization and systematization identified that the works are linked to 47 different universities, of which 12 stand out for the large volume and continuity of research produced. To analyze the specificities of these productions, Bardin's content analysis (2016, p. 121) was used, following the steps of "pre-analysis; exploration of the material; treatment of results; inference; and interpretation". Applying this technique, the next phase explored each publication individually to identify the main professors, the concepts and the context of the applicability of the investigations.

5 RESEARCH RESULTS

The data showed that some professors from these universities became national and international references in theoretical and literary production on collaborative networks in science.

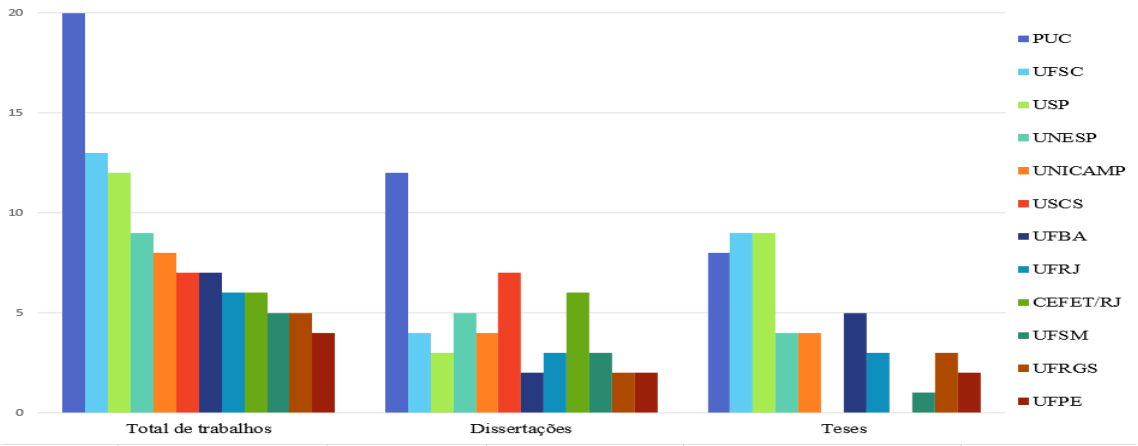
As presented in descending order of publications of theses and dissertations, the 12 universities highlighted are: the Pontifical Catholic University of São Paulo (PUC) with 20 works; the Federal University of Santa Catarina (UFSC) with 13 papers; the University of São Paulo (USP) with 12 papers, the São Paulo State University Júlio de Mesquita Filho (UNESP) published 9 papers; in the sequence appears with 8 works the State University of Campinas (UNICAMP); the Municipal University of São Caetano do Sul (USCS) and the Federal University of Bahia (UFBA) produced 7 studies each; produced 6 works each the Centro

[17] The result of the research in the Capes repository pointed to 165 works; however, after investigation and several rescue attempts with the authors and advisors by e-mails, phone calls and social networks, it was possible to locate 160 publications for categorization.

Federal de Educação Tecn. Celso Suckow da Fonseca (CEFET/RJ) and the Federal University of Rio de Janeiro UFRJ; the Federal University of Rio Grande do Sul (UFRGS) published 5 studies. Finally, the Federal University of Pernambuco (UFPE) and the Federal University of Santa Maria (UFSM) published 4 studies each.

The first work available in the catalog is a dissertation produced at UFRJ supervised by professor Vera Helena Ferraz de Siqueira in the large area of human sciences in education. Since the beginning, the term networks has been very diversified in terms of its application, in this case, linked to research on sexuality, gender and the textbook with the aim of contributing to teaching practice.

Graph 1. Twelve most productive Brazilian universities on the topic of collaborative networks in stricto sensu between 01/2001 and 12/2020.



Source: own elaboration.

It was found that these 12 universities together produced 101 works, 53 theses and 48 dissertations, corresponding to 62.34% of Brazilian production in stricto sensu over the past 20 years. While the other 35 educational institutions together produced only 37.66% of the works.

Among the 12 prominent universities, the analysis showed that some have professors who guarantee continuity and periodicity in the production of research on the subject, as described below.

PUC produced 20 research projects, 12.34% of the national production [out of 160 works] and 19.80% of the production of the 12 universities [101 works], of which 50% were supervised by Professor Cecília Almeida Salles. UFSC published thirteen works, four dissertations and nine theses, 8.12% of the national production and 12.87% of the research of the most productive universities between 2007 and 2017, among these nine researches

69.23% being 6 theses and 3 dissertation, were guided by Professor Ricardo José Rabelo. USP published nine theses and three dissertations 7.50% of the national production between 2014 and 2019 and 11.88% of the 12 universities, it is noteworthy that eight of these 12 researches, 66.66% of which were supervised by Fábio Muller Guerrini between 2008 and 2019. These three universities are responsible for 27.97% of the national production [of the 160 papers] and 44.55% of the production of the 12 universities that have produced the most in the stricto sensu of Brazil in the last 20 years on collaborative networks.

It should be noted that PUC maintains two centers for studies and construction of knowledge about "collaborative networks", which are very distinct and expressive in the scientific environment, producing research based on the performance of a few professors who continuously guide doctoral and master's students.

On the one hand, the culture of theatre, journalism and representation emerges in the context of collaborative networks with teachers Chistine P. N. de Mello who states "Creating spaces for sharing implies creating communities. It means the power of the collaborative, in which the experience is shared in a network". (Mello, 2017, p. 16 apud Silva, 2020, p. 60). And with professor Cecília Almeida Salles "the options, apparently individual, are inserted in the collectivity of precursors and contemporaries. In this perspective, innovations or ruptures arise in the midst of continuity" (Salles, 2011, p. 112, apud Varassin, 2016, p. 16). In the arts, with the contribution of Salles (2011), she is probably one of the pioneers in our field in bringing the concept of network closer to creative processes in the arts and communication. "Authorship is established in relationships, that is, in the interactions that sustain the network that is built throughout the creation process" (Salles, 2010, p. 225 apud Reichhardt, 2016, p. 91). Creative network, for the authors, is a human tool for the creation and exploration of artistic and journalistic works.

On the other hand, the digital culture, semiotics, technology, cyberculture, cyberspace of research professors Trivinho (2001, 2006, 2007) and Santaella (2008 and 2010). Santaella (2014, p. 15-17) referring to school and networks, the first space of sociability and collaboration to which individuals are inserted, states that, when the internet and digital media began to emerge, "they already promised to shuffle this game [of human relations] in a radical way in the ways of thinking and knowing, in the dispositions to act and in the ways of perceiving and feeling and interacting" referring to the processes of teaching, learning and relating in the educational space. It also discusses that, regarding the 21st century "the human being emerges with digital networks", the relations of education with the new human being that educators have before them, students immersed in the symbiotic world that express

themselves in diverse and different senses and signs, need to be open to intelligence technologies for a re-signification and strengthening of bonds/networks "where sharing, solidarity, controversies and conflicts permeate, but, above all, constitute whether in spaces of dissemination and access to information and knowledge" (Santaella, 2014, p. 15-17). The author concludes that formal and non-formal educational spaces need to incorporate semiotics, which is the science that investigates all languages that produce meaning and senses, in order to continue forming networks with the new generation of students in the technological, virtual and volatile world.

Also a researcher at PUC, Trivinho (1996, p. 74) defined cyberspace as the "most advanced electronic telecommunications network, of which the internet has become the prime example, it redefines, rearticulates and rescales, in an original way, all the elements belonging to the technological, sociological and political dimension of communication" [...] according to the researcher, cyberspace generated cyberculture, which is an unlimited space where activism, independent productions and the possibilities of forming networks of cooperation or citizen relationships take place connected. Finally, the author argues that all electronic media rescale human experiences to the network, and mix the global and the local, which is why they are "glocal" and not global.

Researcher Ricardo José Rabelo, a professor at UFSC, is a reference in correlating the term networks to engineering applications and collaborative organizational networks (RCOs). He is one of the "us" and supervised 6 theses and 3 dissertations between 2007 and 2017. The comparative analysis of the works identified that the term collaborative network is directed to the technological world, innovation environments, organizational and entrepreneurship contexts.

> [...] social networks allow for an effectiveness never seen before in relation to the "transmission of concepts, mobilization initiatives, structuring of collaborative networks and various forms of coordinated social action", giving their users an unprecedented bargaining capacity in the face of traditional holders of power in the social sectors of communication and politics (Rabelo, 2010, *apud* Silva, 2012, p. 124).

In UFSC research there is a focus on the formation and use of networks for the prospect of economic, industrial and technological development through digital communication tools. These relationships have more formal than informal characteristics, and take place through media and digital means with a more intuitive scope and focus on the business world and global technological evolution.

USP is the third university that most produced research, had 12 publications with the term collaborative networks, 9 theses and 3 dissertations, of these, eight researches were guided by Fábio Muller Guerrini between 2008 and 2019. The comparative analysis of the works showed continuity and periodicity from engineering research that identified that "collaboration mechanisms, specifically collaborative networks, can be considered pillars that support innovation, cost reduction and knowledge sharing (Gomes; Marques; Guerrini, 2017 apud Yamanari, 2017, p. 62). In research guided by Guerrini, concern was observed with understanding "information asymmetries" between buyers and sellers, whose individuals [in networks] are intertwined with instabilities, competitiveness, opportunities and risks.

In the scientific productions of the three universities, PUC, UFSC and USP, which together project to society 27.77% of the knowledge produced in the last 20 years in the Brazilian stricto sensu on collaborative networks, it was identified that collaborative behavior reduces disparities and enables gains and collective advances.

All these human relationships in science that emerge from Universities, prodigious or contemporary, recorded in diverse and different ways, have a symbiosis that opportunely generate knowledge called intellectual networks that requires some specificities. The thinker Devés-Valdés (2007) responding to the question: What is an intellectual network? He states that, firstly, it is necessary to distinguish between temporary or casual contacts and the constitution of a network. For him, density makes it possible to understand which are the most active cores of a network and the moments of greater or lesser vitality that characterize it. As for its members, "this is understood to be a group of people engaged in the production and diffusion of knowledge, who communicate with each other due to their professional activity, over the years (Devés-Valdés, 2007, p. 30).

For Devés-Valdés (2007) the production of knowledge in networks has the potential to "calibrate" to measure the circulation of tangible or intangible, cultural and symbolic goods of a group, with a leading role in achieving political and cultural hegemony at certain times. The author concludes by calling for the union of Latin American intellectuals "the current time demands collaboration among all to forge an international republic of thought, a collaboration that can contribute to the reform of our intellectuality" (Devés-Valdés, 2007, p. 28, translation our).

Finally, Wiener (1965, p. 16), creator of cybernetics, saw communication as "the cement of society" and declares that in the universe everything is communicated through language, which is considered to produce reality as it actually engenders social relations. Faced with technological advances, the same author states that "society can only be

understood through a study of the messages and communication facilities available".

It becomes progressively consensual that the social aspects of science are constantly refined and expanded by the development of new research that generate new knowledge and knowledge, those that result from the movements of these actors [university professors, researchers] who for decades produce research in Brazil.

6 CONCLUSION

The historical rescue pointed out that the production of knowledge and knowledge in collaborative networks is an action present since the middle ages when artisans and apprentices met in clubs initially in England to share inventions and socialize knowledge among their peers, to what we know as Invisible Colleges.

With technological evolution, these networks expanded, took on new forms and became part of globalized scientific production. Especially in Brazil, 47 stricto sensu teaching institutions have carried out research on the subject in the last 20 years. Contributing to the spread of the term to the most diverse areas of knowledge. Applied social sciences stands out in the large area of knowledge with 43.33%; followed by the engineering area with 19.58%; multidisciplinary area with 14.83% and human sciences with 14.16% of production. Agricultural, biological, linguistic, arts, health and literature sciences share the remaining 9.09%.

The 12 universities that produce the most research on collaborative networks are located in the south, southeast and northeast regions, of which eleven are public institutions. However, the most productive researcher is part of PUC's teaching staff, Professor Cecília Almeida Salles of the communication and semiotics program, in the concentration area 'sign and meaning in communication processes', which includes the line of research 'process of creation in communication and culture'. It is observed that of the 20 works produced by PUC, 12 are from the great area of knowledge of applied social sciences under the care of advisors with a lower incidence of research, but that contribute to the strengthening of the program as Maria Lúcia Santaella Braga who is a reference in intellectual production and one of the main disseminators of semiotics and Charles Peirce's thought in Brazil, with more than 40 books published since 1980. USP are the 'nodes' that bring together more people with the aim of developing new knowledge in their specific areas of research. They introduce programs in these universities that bring together professors with multiple backgrounds, these multidisciplinary and interdisciplinary groups are active in the research of collaborative

networks, tracing new paths through stricto sensu research projects that address new and different applicability to the term.

These groups of researchers at universities are the contemporary Invisible Colleges that recognize the importance of solidarity and otherness, as a conception of the basic assumption that every social human being interacts and is interdependent on the other, especially in the production of science.

Finally, the theoretical framework and data systematization showed that: from the world of work to the arts, from social to educational or economic and technological, the development of relationships in networks in science favors the construction of visible and invisible structures, which promote non-hierarchical values, with a view to producing knowledge that positively impacts the most diverse structures of society, for the solution of relevant problems, which would hardly be possible individually.

This research made it possible to learn about the expansion of the concept of networks and understand how it presents itself in the face of the need for collective solutions. However, in addition to the aforementioned theoretical unfolding, it seems reasonable to suggest that more research be carried out correlating Brazilian and international protagonists [university professors stricto sensu] for a broader understanding of the production of knowledge in collaborative networks that go beyond current approaches, given the remarkable expansion communication science and its transforming potential in the world.

REFERENCES

BARDIN, L. (2006). *Análise de conteúdo*. 70.

BERNAL, J. D. (1939). *The social function of science.* London George Routledge Sons Ltd. Broadway house- 6s-74 carter lane, t'.c.4, p. 415-416.

BEAVER, D. R. (1978). *Studies in scientific collaboration*. September. Scientometrics, 1 p. 65-84. DOI: 10.1007/BF02016840.

BOYLE, R. (1645). *The Works of Robert Boyle: Unpublished writings*. (1645-1970). Disponível em: https://books.google.com.br/books/about/The_works_of_Robert_Boyle.html?id=D7raAAAAMAAJ&redir_esc=y. Acesso em: 25 nov. 2021.

CASTELLS, M. (1999). *A sociedade em rede* / Tradução Roneide Venâncio Majer / São Paulo: Paz e Terra, 3v. v.1. (aids.gov.br). Acesso em: 4 jan. 2022.

CASTELLS, M. (2000). *O poder da identidade*. Tradução Klauss Brandini Gerhardt. 2. ed. São Paulo: Paz e Terra. p. 530 A Era da Informação: economia, sociedade e cultura, 2.

CRANE, D. (1972). *Invisible colleges: diffusion of knowledge in scientific communities*. Chicago, University of Chicago Press.

DEVÉS-VALDÉS, E. (2007). Introducción: la noción ―redes intelectuales y sus significados para los estudios ideológicos y para pensar el futuro intelectual latinoamericano. Redes intelectuales en América Latina. *Hacia la constitución de una comunidad intelectual*. Santiago: IDEA-USACH, 2007, p. 29-36 (Colección Idea. Segunda Época). Disponível em: http://www.cecies.org/imagenes/edicion_408.pdf. Acesso em: 29 out. 2021.

FACCIN, K. (2010). C*apital social e competitividade em redes colaborativas vitivinícolas da serra gaúcha: estudo de casos das redes APROVALE e APROBELO'* 01/04/2010 203 f. Mestrado em Administração Instituição de Ensino: Universidade de Caxias do Sul: Biblioteca Central da Universidade de Caxias do Sul.

FERNANDEZ-CANO, A.; TORRALBO, M.; VALLEJO, M. (2004). Reconsiderando o modelo de crescimento científico de Price: Uma visão geral. *Scientometrics* 61- 3-2004, p. 301-321. Disponível em: https://eurekamag.com/research/012/489/012489098.php Acesso em: 4 jan. 2022.

GARFIELD, E. (2006). *Citation indexes for science. A new dimension in documentation through association of ideas*. REPRINTS AND REFLECTIONS. 1955 p. 1123. Publicado pela Oxford University Press em nome da International Epidemiological Association International Journal of Epidemiology. Disponível em: https://academic.oup.com/ije/article/35/5/1123/762383. Acesso em: 14 ago. 2021.

HAGSTROM, W. (1065). *The scientific community*. New York: Basic Books. Disponível em: http://garfield.library.upenn.edu/classics1989/A1989R700900001.pdf Acesso em: 4 jan. 2022.

HANNEMAN, R. A. (2001). *Introduction to social network methods*. Califórnia: Universidade da Califórnia. Disponível em: Introduction_to_Social_Network_Methods.pdf (ucr.edu). NETTEXT.PDF Acesso em: 4 jan. 2022.

MACIAS-CHAPULA, C. A. (1998). O papel da informetria e da cienciometria e sua perspectiva nacional e internacional. *Revista Ciência da Informação*. Coleção 20 Out 1998 p. 134-140. Disponível em: https://www.scielo.br/j/ci/a/rz3RTKWZpCxVB865BQRvtmh/?lang=pt. Acesso em: 18 jun. 2021.

MEADOWS, A. J.; CONNOR, J. G. (1971). *Bibliographical statistics as a guide to growth points in science*. Department of Astronomy. University of Leicester. Disponível em: https://journals.sagepub.com/doi/pdf/10.1177/030631277100100107 Acesso em: 4 jan. 2022. Milgram, S. T. (1967). The Small World Problem. *Psychology Today*. p. 60-70.

MERTON, R. K. (1945-2013). *Ensaios de sociologia da ciência-coleção sociologia da ciência e da tecnologia*. Editora 34, SP.

MENDENHALL, M.; HIGBEE, K. (1982). *Tendências recentes em autoria múltipla em Psicologia*. PUB DATA Abr 82NOTA12p.; Artigo apresentado na Reunião Anual do Western Psychological Association 1982 (62nd, Sacramento, CA, 7-11 de abril de 1982). Disponível em: ed222807.tif.pdf (psu.edu). Acesso em: 25 nov. 2021.

NETTO, J. P. (2016). Ainda vale a pena ler J. D. Bernal, o sábio. *Blog da Boitempo*. Disponível em: https://blogdaboitempo.com.br/2016/06/10/ainda-vale-a-pena-ler-j-d-bernal-o-sabio/ Acesso em: 4 jan. 2022

PRICE, D. de S. (1963). *Little Science, Big Science*, New York: Columbia University Press.

PRICE, D. de S. (1965). *Networks of Scientific Papers*, in Science 149 (3683). p. 510-515.

PRICE, D. de S. (1966). *Collaboration in an invisible college*. American Psychologist, 21(11). p. 1011–1018. https://doi.org/10.1037/h0024051.

PRICE, D. de S. (1976). A general theory of bibliometric and other cumulative advantage processes. In *Journal of the American Society for Information Science* 27. 1976, p. 292-306. Winner of 1976 JASIS paper award.

PRICE, D. de S. (1986). *Little science, big Science and beyond.* Columbia University Press New York.

SILVA, K. R. (2020). *Performatividade e cinema contemporâneo: procedimentos nas extremidades em Gabriel Mascaro'* 29/05/2020 undefined f. Mestrado em Comunicação e Semiótica Instituição de Ensino: Pontifícia Universidade Católica de São Paulo, São Paulo Biblioteca Depositária: PUC/SP.

SANTAELLA, L. (2000). *Navegar no Ciberespaço*. O perfil cognitivo do leitor é imersivo. São Paulo: Paulus.

SANTAELLA, L. (2007). *Linguagens Líquidas na Era da Mobilidade*. São Paulo: Paulus. 2007.

SANTAELLA, L. A Ecologia Pluralista da Comunicação. Conectividade, mobilidade, ubiquidade. São Paulo: Paulus. 2010.

SANTAELLA, L. (2014). A aprendizagem ubíqua na educação Aberta. *Revista Tempos e Espaços em Educação*. Volume 7, Número 14 - setembro/dezembro 2014.

SMITH, M. (1958). The trend toward multiple authorship in psychology. *American Psychologist*, 13(10). 1958 p. 596–599. https://doi.org/10.1037/h0040487. Disponível em: https://psycnet.apa.org/record/1960-00275-001 Acesso em: 4 jan. 2022.

SILVA, Taís C. (2012). A tutela dos direitos de personalidade das pessoas jurídicas nas redes sociais.' 01/03/2012 230 f. Mestrado em Direito Instituição de Ensino: Universidade Federal da Bahia, Salvador Biblioteca Depositária: Biblioteca da Faculdade de Direito da UFBA Storer, N. W. (1966). The social system of science. New York: Holt, Rinehart and Winston. p.180.

TRIVINHO, E. *O mal-estar da teoria: a condição da crítica na sociedade tecnologia atual*. Rio de Janeiro: Quartet. 2001.

TRIVINHO, E. (2006). A condição transpolítica da cibercultura: ruína do Estado e da política na civilização mediática avançada. São Paulo: 2005. Cópia reprográfica e digital. *Revista*

Famecos: mídia, cultura e tecnologia, editada pelo Programa de Pós-Graduação em Comunicação Social da PUCRS, Porto Alegre: EDIPUCRS, n. 31, dez. 2006.

TRIVINHO, E. (2007). Cibercultura e existência em tempo real. Contribuição para a crítica do modus operandi de reprodução cultural da civilização mediática avançada. *E-Compós*, 9. https://doi.org/10.30962/ec.151.

VANZ, S. A. de S.; STUMPF, I. R. C. (2010). Colaboração científica: revisão teórico-conceitual. *Perspectivas em Ciência da Informação*. v.15, n.2.

ZIMAN, J. (1979). *Conhecimento público: a dimensão social da ciência*. Tradução de R. R. Junqueira. São Paulo: Edusp.

VARASSIN, A. (2016). Processos transmidiáticos de criação: obra em progresso, de Caetano Veloso, 12/05/2016 undefined f. Mestrado em Comunicação e Semiótica Instituição de Ensino: Pontifícia Universidade Católica de São Paulo, São Paulo PUC/SP.

YAMANARI, J. S. (2017). Empresa S^3: caracterização do princípio de colaboração 01/09/2017 144 f. Mestrado em engenharia de produção Instituição de Ensino: Universidade De São Paulo (São Carlos), São Carlos.

WIENER, N. (1965). *Cybernetics: Or control and Communication in the Animal and the Machine*. New York: The MIT Press.

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