

STUDIES OF AUTHOR COCITATION ANALYSIS: A BIBLIOMETRIC APPROACH FOR DOMAIN ANALYSIS

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ABSTRACT

Author Cocitation Analysis (ACA) can be defined as the analysis of a group of actors, writers or researchers structurally organized in a (social and cognitive) network of a particular scientific community. The greater the number of researchers selected, the greater the amplitude and the domain boundary under consideration; the more restricted the number of researchers chosen as representative and appropriate, the less extensive the domain. From the perspective of the first axis of Tennis (2003), the selection of authors involves setting parameters on the extent of the domain, i.e., its total scope and amplitude. Thus, from the point of view of Tennis's (2003) approach to Domain Analysis, the selection of authors for Author Cocitation Analysis is associated with the designations and boundaries of the domain, as well as to their goals (Tennis, 2003). Still, the selection of authors through the most cited authors in the literature, reflects the core elements of a domain and constitute the most specific foundation of a domain, aligning to the Degrees of Specialization characterized by Tennis (2003). It is concluded that the Author Cocitation Analysis (ACA) is a relevant procedure to the analysis of the underlying structure of a scientific knowledge domain, which meets the theories and concepts of Domain Analysis researchers, in that it allows characterizing the science, identifying, analyzing and assessing the conditions under which scientific knowledge is constructed and socialized.

Keywords: Author Cocitation Analysis .Domain Analysys. Author Cocitation Analysis

1 INTRODUCTION

First used in 1980 in the area of Computer Science by Neighbors with the aim of identifying objects and relationships in a given domain perceived as important by specialists (Kerr, 2003), Domain Analysis (DA) supports the studies that seek to acknowledge an area of knowledge, activity or interest, in which professional groups are articulated in both thought and language. Thus, the concept of domain can be understood as an area of knowledge, a group of individuals working together in an organized way, or a set of publications (Mai, 2005).

In the context of Information Science, Birger Hjørland was the first to use this concept in partnership with Hanne Albrechtsen, basing their theory and methodology (Hjørland, 2002b). Hjørland (2002a) presents 11 approaches to Domain Analysis, among them the bibliometric studies. The author points out that the combined use of more than one of these approaches enriches the analysis and understanding of a domain and, furthermore, that the bibliometric studies constitute a consistent and objective approach to analyze and characterize a scientific domain.

Among the bibliometric studies, the author highlights the contribution of citation and cocitation analysis, especially with regard to visualization of scientific knowledge areas. As a principle, cocitation analysis understands that when two documents or authors are jointly cited in the literature, there is a subject proximity between the cited, from the citing author's perspective. These studies are based on the frequency with which two authors or documents are cited jointly in scientific production of a field and show how the knowledge structure of an area is perceived by its researchers. Thus, the higher the cocitation frequency, the closer relationship between these cited authors.

From the questions listed, generally, this study aims to describe and understand Author Cocitation Analysis (ACA) procedure as an approach for Domain Analysis (DA). More specifically, it proposes to discuss the fundamental aspects of Author Cocitation Analysis from the concepts presented in AD theory, and the possible complementarity and articulation with other approaches of this theory. Still, this study proposes to search, in the scientific literature, applications of Author Cocitation Analysis as an approach that characterizes a scientific field.

As methodological procedures, this study is characterized by being theoretical, in order to contribute to a better understanding of the conceptual and methodological foundation for the Author Cocitation Analysis (ACA), which involves citation and cocitation analysis in the most current approaches and treatments. It is also of documentary nature as it brings examples of Author Cocitation Analysis applications from the disseminated scientific literature through formal channels relevant to the area of Information Science, such as events and publications, among others, to characterize a domain.

2 BIBLIOMETRY AS AN APPROACH TO DOMAIN ANALYSIS: THE CONTRIBUTION FROM AUTHOR COCITATION STUDIES

The concept of Domain can be understood as a field of study in their different specialties, a set of literature on a particular subject or group of people working together in an organization, comprehending the study of a discourse community, and the role this community played in science (Mai, 2005; Hjørland and Albrechtsen, 1995). In this context, the notion of knowledge domain encompasses both the conceptual universe and the way in which a given discourse community is formed (Llorens et al., 2004; Thellefsen and Thellefsen, 2004; Mai, 2005).

Thus, a domain can be a scientific discipline, an area of scientific knowledge or a discourse community related to a political party, religion or any other group. Hjørland and Albrechtsen (1995, p.400) define domains as "thought or discourse communities, which are parts of society's division of labor", hence their social and cultural foundations.

Within the domain analysis area, integration between the individual and the social context of the communities is sought, where they are inserted, and the concepts of information become meaningful when sharing occurs between these different communities and their members.

Hjørland (2002a) highlights 11 approaches by which one can analyze a domain. The different approaches to Domain Analysis, according to the author are: production of literature guides, production of special classifications and thesauri, indexing and information retrieval, empirical user studies, bibliometrical studies, historical studies, genre and document studies, epistemological and critical studies, terminological studies, structures and institutions in scientific communication, cognition, knowledge and artificial intelligence.

Other researchers have studied the issues related to Domain Analysis. Tennis(2003) notes that it is necessary to know the core and boundaries of certain knowledge to analyze a domain, regardless of its magnitude. The author focuses his studies on domain, especially on methodological issues, rather than on conceptual issues, i.e. those procedures that operationalized, define domains. His methodological conception seeks the construction of a methodological trajectory that can be transferred and understood by other domain analysts, in their different laterality.

In this study, the cited author proposes two axes from which the domain analysis can be addressed: the Areas of Modulation, which determines the extension of a domain, and the second axis, the Degrees of Specialization, which determines the depth and specificity.

The first axis establishes the parameters on the names and extension of the domain, i.e., its full scope and amplitude. Thus, the areas of modulation establish “parameters on the names and extension of the domain” (Tennis, 2003, p.193). The second axis refers to the Degrees of Specialization, from which Tennis (2003) establishes the intensity and depth of a domain. In this context, the Degree of Specialization qualify and establish the specificity of a domain, either from its focus (parameter used to describe a given domain), or through the boundaries and intersection with other domains, creating new domains or not, as they may intercept or not, and other Degrees of Specialization.

The author highlights that these two axes are flexible: sometimes the extension is increased and the intensity is diminished and vice versa. Thus, the Modulation Areas and the Degrees of Specialization must be defined, noting that in relation to the latter axis, which an intersection with another domain may occur, may be understood as a new domain or not, due to the proximity to several scientific fields.

In domain analysis, especially in Knowledge Organization, Smiraglia (2011a) highlights the importance of all people interact theoretically through geopolitical and cultural borders. Using domain analysis, it is possible to assess what is actually important or significant in a given field, so that aspects such as trends, patterns, processes, dominant thoughts, agents and their relationships can be identified and analyzed.

According to Capurro (2003), special emphasis is given to the study of connections, links and associations that occur in discourse community, its different perspectives, points of view, approaches or controversies or in user communities in different fields of knowledge.

In summary, on the international Information Science, Domain Analysis has been traditionally worked, in theoretical terms and applied by Hjørland and Albrechtsen (1995), Hjørland (2002a, 2004), Tennis (2003), Smiraglia (2011a) and Capurro (2003), among others, and constitute relevant approach for science characterization and assessment, in that it allows to identify and analyze the conditions under which scientific knowledge is constructed and socialized.

Among the different approaches of Domain Analysis, these authors consider the “Bibliometric Studies” as objective and consolidated methodologies for analysis and identification of a scientific domain and are unanimous in pointing out the advantages of articulating that study with epistemological and historical approaches or others of qualitative nature.

These studies involve a broad set of indicators, which are grouped in Indicators of Production, Indicators of Citation and Indicators of Link (Okubo, 1997; Spinak, 1998; Narin et al., 1994; Callon et al., 1993). Among the different aspects analyzed, these indicators show the researchers, the themes, institutions, knowledge areas, more fertile or more productive countries, as well as the front research of a knowledge field, collaboration networks among scientists, groups, institutions or countries and citation and cocitation networks (Grácio and Oliveira, 2011).

Studies of citations and cocitations are relevant procedures for analyzing interlocution among researchers and their role in different areas of science, as they contribute to the visualization of communicative and interactive process, as well as the underlying structure of a knowledge domain.

The set of references to scientific papers can thus be analyzed as a reflection of a discourse community, so as to constitute a domain. Its study is based on analyzes of citation frequency, whether of authors or documents, and co-occurrence frequencies (cocitation) between them.

The citation analysis identifies researchers with greater impact on the area and gives visibility to the theoretical references that support it, as well as its concepts, objects and methods, contributing to the understanding of a scientific community (Oliveira, Grácio and Silva, 2010). In addition, it allows identification of groups of scientists and their publications, and elucidate researchers of greater impact in an area (Glänzel, 2003), as well as “vanguard” researchers that construct new knowledge in the area, thus pointing paradigms, relevant methodological procedures. Also according to Smiraglia (2011b), the citations define the domain.

The study of cocitation, derived from citation analysis, examines the frequency with which two authors or documents are jointly cited in the production of a scientific area. According to Miguel, Moya Anegón and Herreno Solana (2008), cocitation analysis produces valid representations of the intellectual structure of a scientific domain, whether of documents, authors, journals, specialties or knowledge fields. Its fundamental premise states that when two or more documents, authors or journals are jointly cited in a further work, there is a similarity between the subject cited, at least from the perspective of the citing authors (Smiraglia, 2011b), and that the greater cocitation frequency, the closer the relationship between them. Thus, in cocitation analysis, the authors jointly cited can present in addition to similarity, complementarity, overlapping or contrasting ideas.

According to Gmür (2003), the cocitation frequency between two authors also determines how the knowledge structure of an area is perceived by the researchers. The references of authors jointly cited produce a valid representation of intellectual structure of a scientific domain.

Other scholars theoretically support the issue of citation and cocitation analysis. Henry Small, one of the first scholars in cocitation analysis, addresses the frequency of documents jointly cited in further literature. According to the author, “when scientists agree on what constitutes prior relevant literature, including what is significant in that literature, they are in fact defining the structures of their communities” (Small, 2004, p.72). He continues: “structure of science is generated by patterns of co-recognition” (Small, 2004, p.71). Thus, “when documents are co-cited, citing authors are awarding recognition as well as creating an association of meanings” (Small, 2004, p.76).

The author also notes that cocitation can be used to establish the core of literature within certain topic or area. In Small's approach, it is perceived that cocitation analysis offers subsidy for other Domain Analysis approaches, such as the production of literature guides, production of special classifications and thesauri, historical studies, genre and document studies and epistemological and critics studies.

According to White and McCain (1998), studies on author cocitation analysis (ACA) had as precursors White and Griffith in 1981, and its main function is to identify influential authors and show their interrelations, from recorded citations.

McCain (1990) highlights that the ACA premise is to analyze the intellectual structure of a given area, scientific field or group of researchers, showing its social and cognitive structure and research domain. The author claims that the ACA assumes that researchers with similar research problems cite similar and close informational sources. Accordingly, ACA can be defined as the analysis of a group of actors, writers or researchers structurally organized in a (social and cognitive) network of a particular scientific community.

3 ACA METHODOLOGICAL PROCEDURE: SOME APPLICATIONS IN LITERATURE TO CHARACTERIZE A DOMAINS

For author cocitation analysis, McCain (1990) presents six steps in the methodological procedure, which were thus adapted in Fig. 1.

At first, ACA studies are demarcated by the initial selection of authors. For this selection, McCain (1990) presents, as possibilities, the selection of authors through the scientific literature in the area, as well as consultation with field specialists and lists of participants in scientific events and awards.

When based on a selection from the scientific literature in the area, this selection shall be adequate and representative, noting that those cited authors in a greater number of papers, i.e., the "classics" take part in this selection (Spinak, 1996).

Adopting this procedure, Smiraglia (2011b) presents a bibliometric analysis of the 11th ISKO International Conference, through a collection of citations in 65 oral presentations showed at the event. For the cocitation analysis, the researcher selected the most cited authors by the participants of that conference. From this selection, a first cocitation analysis was conducted exclusively among the conference participants. A second cocitation analysis was performed from the same set of most cited authors in the ISKO 2011 conference, but seeking the cocitation frequencies of these authors in Web of Science database in order to produce a visualization of how the domain extracted from the conference core is perceived and seen by Knowledge Organization scientists, globally, that is, a broader view of how the area is co-recognized (Smiraglia, 2011b).

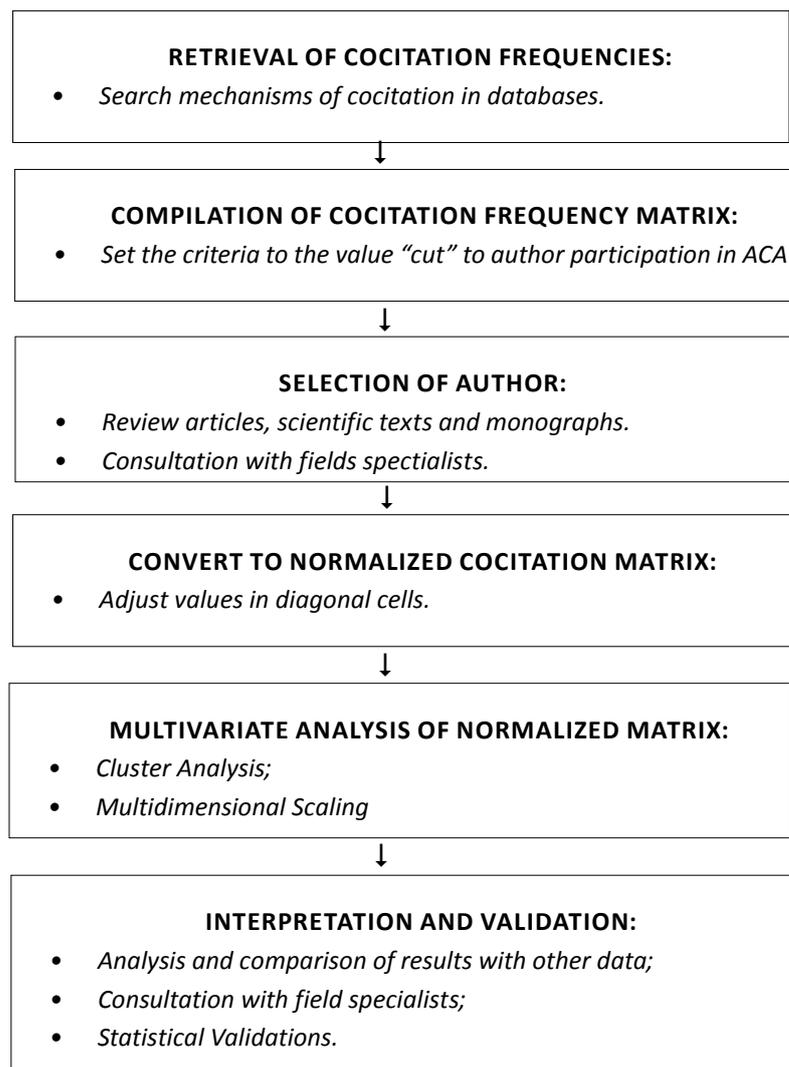


Figure 1. Six steps in ACA methodological procedure

Source: Adapted from McCain (1990)

Also using the procedure observed by McCain (1990), Liberatore, Herrero-Solana and Guimarães (2007) conducted a study in order to identify and visualize the profile of the Brazilian journal named *Ciência da Informação*, through citation and cocitation analysis, considering that this is one of the most prestigious journals in the field in Brazil. All articles published in this journal in the period 2000-2004 were collected. From the citation analysis of the articles published in this journal, a core of the 25 most cited authors was selected, for which a cocitation network was constructed.

Custódio (2012) aimed to identify the main theoretical trends in the line of research: “Teaching, School Learning and Human Development” from Graduate Program in Education at Universidade Estadual Paulista, UNESP, Marília through citation and cocitation analysis from the set of dissertations and theses produced in the period from 2004 to 2009. The author collected 48 scientific papers: 25 master dissertations and 23 doctoral theses. For the cocitation analysis, by academic level, the author selected the most cited authors in a total of 34 authors to Masters and 29 authors for the Doctorate.

Moreover, Oliveira, Grácio and Silva (2010) aimed to identify the scientific characters of Knowledge Organization and Representation (KOR) field, seeking to highlight the research front on this Information Science theme under Brazilian researchers’ perspective, through citation and cocitation analysis. The authors collected the citations made in the 134 papers presented in the five

meetings of the National Research Meetings of the National Association for Research and Graduate Studies in Information Science (ENANCIBs) in the period from 2003 to 2008. For the selection of authors participating in the ACA, the most cited authors were considered, totaling 31 authors, for which the cocitation frequency was recorded.

Using the Scopus database, Oliveira and Grácio (2012) found the authors that have grounded the Brazilian research with international insertion in the area of Bibliometrics and Scientometrics, through citation and cocitation analysis of Brazilian articles, published in the journal *Scientometrics*. 53 articles were found, with 741 references and 19 authors cited three or more times. From these most cited researchers, the author cocitation analysis was performed.

Still, in this first methodological step, aiming at the selection of authors via consultation with specialists, Guimarães, Oliveira, Grácio and Fernández-Molina (2011) identified, from the academic universe of Librarianship and Documentation in Spain, which theoretical references - Spanish and foreign - that this community recognizes as significant to the epistemological construction area of Document Analysis of content, and also to what extent these authors establish dialogue. A set of 19 Spanish investigators, working specifically in the area, answered a questionnaire regarding which authors - Spanish and foreigners - they regarded as significant for the epistemological construction area of Document Analysis of content. As a result, from the analysis of the questionnaires, a total of 275 citations, with 164 different authors cited was obtained. For cocitation analysis, the authors mentioned at least 3 times by the set of respondents were considered. Grounded on this criterion, 15 authors were selected for the Author Cocitation Analysis study.

Most of these researches on cocitation analysis, through the selection of the most cited authors, were conducted in order to analyze a domain, identifying how the discourse community co-recognizes their theoretical reference, although in some of these studies the domain analysis foundation was not explained.

After this first step, cocitation frequency retrieval followed, when search mechanisms for cocitation search in databases may be used. White (1986) presented three strategies for online searchers to retrieve cocited pairs of authors in order to contribute to optimizing the frequency of authors jointly cited, making the search in the Web of Science more accessible. Analogous procedure can be performed in Scopus database, in "advanced search" dialog box, using the operator "REFAUTH (author_name 1) AND REFAUTH (author_name 2)." This search function in Scopus retrieves the documents present in this database, wherein author 1 was jointly cited (cocited) with author 2.

However, when the data are not systematized, in a friendly way, as in these international databases, the retrieval of cocitation frequencies occurs manually. Grácio and Oliveira (2013) show, in detail, the construction of a cocitation frequency matrix collected manually in unindexed documents, in a friendly way, for author cocitation studies. From the selection of the most cited authors, the authors proposed the construction, using the software Excel, of an asymmetric matrix of citation occurrence between citing authors (per line) and cited authors (per column), where for each column (cited author) the value of one is entered on the corresponding line (citing author) where he was cited and the value of zero when the author was not cited for the paper. From this occurrence matrix, it was constructed, also through Excel using the mathematical function "SUMPRODUCT", the symmetric square matrix of cited authors, whose result constituted the cocitation frequency among the most cited authors in the analyzed studies.

In the third step, named Compilation of Cocitation Frequency Matrix, was the moment to establish the criterion for "cut-off" value for the authors' participation in the ACA. However, this procedure is necessary when the number of cocitations is very large, with many low frequencies of cocitation,

making it difficult to visualize the most significant similarities and proximities between authors. Given the simplicity of the procedure, applied examples were not sought in the literature.

In the step “Conversion to Normalized Cocitation Matrix” when normalization is made using the Pearson correlation, it is necessary to adjust the values in the diagonal cells. To this end, the literature suggests at least two procedures: White and Griffith (1981) adjusted the diagonal value by replacing it with the greatest cocitation value of the analyzed author with the other authors; McCain (1990) uses missing (missing data) to adjust the diagonal values.

Another way to convert the cocitation frequency matrix into a normalized cocitation index matrix is to use the Jaccard index or the Salton Cosine. The normalized matrix are derivatives from cocitation frequencies, through the conversion of integer values (observed) into values that relativize cocitation intensity of two authors, in relation to the amount of citations received individually by each of the cocited authors.

All procedures cited for normalization of cocitation matrix result in values ranging between zero and one: the closer to one, the more similar (highly cocited) the two authors; the closer to zero, the more distant (less intense) the association between them.

Furthermore, although the absolute cocitation frequencies are used and accepted as useful tools in the scientific measurement of connectivity between the cocited authors, the normalized values can reveal, more consistently, aspects underlying the intellectual structure of a scientific field that are not identifiable through cocitation analysis based on absolute frequencies.

For some authors, as Leydesdorff and Vaughan (2006), the cocitation matrices - observing (absolute) frequencies - can be used in the construction of cocitation networks or multidimensional scaling maps (MDS), however they contain less information than relative cocitation index matrices. Small and Sweeney (1985) point that cocitation analyzes based on relative cocitation indexes provide a more comprehensive representation of the theoretical references groups that form the scientific domain.

Thus, normalized matrices have been preferably used in multivariate cocitation analysis studies, the fifth step in McCain (1990) methodology for providing more refined results and being sustained in probability theory. Smiraglia (2011b) used, in combination, two multivariate procedures in author cocitation analysis: MDS (Multidimensional Scaling) as a resource to view the proximity of the authors, according to cocitation similarities, combined with Cluster Analysis, which enables to identify groups or “communities” perceived by citing authors with common interest. Still, Guimarães, Oliveira, Grácio and Fernandez-Molina (2011), based on the absolute frequencies matrix, constructed the cocitation network, the latter grounded on Social Network Analysis (SNA) multirrelacional procedure. In this context, Custódio (2012) presented the cocitation network from the matrix normalized through Salton Cosine.

The last phase of the procedure presented by McCain (1990), named Interpretation and Validation, involves the analysis of the results, the intersection of the results with other results, when the data is comparable, as well as consultation with specialists in the field, especially when the study was not is being conducted by researchers in the area that is being applied. It is noteworthy that, as referenced in theory, in the analysis and identification of a scientific domain, scholars are unanimous in pointing out the advantages of articulating bibliometric approaches with epistemological, historical or other qualitative approaches. The consultation with specialists in the field strengthens bibliometric studies, bringing epistemological, theoretical, historical and social elements to the context of cocited researchers contributing to the validation and interpretation of ACA studies. Custódio (2012),

for the interpretation phase of the cognitive structure in constructed cocitation networks, used questionnaires sent to specialists in the field, who were asked to identify groups of researchers that represented theoretical or methodological trends in the area of the presented cocitation network, as well as if the researchers considered other relevant researchers to the topic discussed that were absent in the constructed cocitation network.

Still, as for the statistical validation, this is necessary when the results originate from sample data.

4 CONCLUSIONS

This research sought to describe and understand the Author Cocitation Analysis (ACA) procedures as an approach for Domain Analysis (DA), discussing aspects of this bibliometric procedure, based on the concepts presented in DA theory and complementarity and coordination with other approaches of this theory.

Tennis (2003) highlighted the need to understand the core and boundaries of certain knowledge as a premise for the analysis of a domain, and thus provided grounds for the first step for ACA - "initial selection of authors." When selecting the authors through the scientific literature in the area, as well as consultation with specialists in the field and lists of participants in scientific events and awards, the Modulation Ares is established, in that when defining the list of researchers who make up the ACA study, the domain extension is determined. The greater the number of researchers selected, the greater the amplitude and the domain boundary under consideration; the more restricted the number of researchers chosen as representative and appropriate, the less extensive the domain. From the perspective of the first axis of Tennis (2003), the selection of authors involves setting parameters on the extent of the domain, i.e., its total scope and amplitude. Thus, from the point of view of Tennis's (2003) approach to DA, the selection of authors for Author Cocitation Analysis is associated with the designations and boundaries of the domain, as well as to their goals (Tennis, 2003).

Still, the selection of authors through the most cited authors in the literature, reflects the core elements of a domain and constitute the most specific foundation of a domain, aligning to the Degrees of Specialization characterized by Tennis (2003).

In the third step, when the criterion to determine the 'cut-off' value in cocitation frequency is established, what is actually important or significant in a given domain is defined, the set of people and significant interactions. The importance of assessing aspects as dominant thoughts, trends, patterns, processes, agents and relationships, highlighted by Smiraglia (2011a), is revealed by this criterion of determining the minimum cocitation frequency occurred among cocited authors that were considered significant.

The fourth and fifth steps of the ACA studies, in which the cocitation frequency values are normalized in order to reveal underlying aspects of the intellectual structure of a scientific field, providing a more comprehensive representation of the theoretical reference groups forming the scientific field, coincide with Capurro (2003) who claims that DA acquires special attention to the study of existing connections and links in the discourse community, showing their different perspectives, theoretical and methodological proximities or controversies.

The Interpretation and Validation step of Author Cocitation Analysis presented by McCain (1990) and effected by consulting specialists in the field, is aligned with Hjørland's (2002a) proposal, as it

points to the advantages of coordinating bibliometric studies jointly with epistemological, historical or other qualitative approaches, granting greater consistency and consolidation to these studies.

It is concluded that the Author Cocitation Analysis (ACA) is a relevant procedure to the analysis of the underlying structure of a scientific knowledge domain, which meets the theories and concepts of Domain Analysis researchers, in that it allows characterizing the science, identifying, analyzing and assessing the conditions under which scientific knowledge is constructed and socialized.

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