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Design ResearchScape. A visual exploration of Design Research publications

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Abstract: In this paper we mix methods and approaches from scientometrics, co-citation analysis and network science, in order to build a set of maps and visualizations of the Design Research field. Bringing together this approaches could give us some tools to get an overview of Design Research discipline as it emerges from an extensive analysis of the scientific publications of the field. This way we provide also a sort of "visual literature review" of the field, a visualization of the discipline, as an alternative approach to already established reviews of the field. We built a dataset by downloading all the citation data from major design research journals (such as Design Issues, Design Studies, International Journal of Design between others) from the Scopus online repository, obtaining a set of more than 1500 papers with all related data about authors, affiliations and references. Methodologies developed in the scientometrics field, such as co-authorship analysis, co-citation analysis, journal mapping, etc., are then performed in order to extract from the dataset some insights on the whole field.

Keywords: Design Research, Scientometrics, Networks, Visualization, Knowledge Domains

1. Introduction

The idea of visualizing an entire discipline, a research area or a "knowledge domain" into a map has been explored and implemented extensively in recent years and a number of case studies exists in many academic fields, but to date a similar approach is not yet applied to the field of Design Research. Methodologies developed in the field of scientometrics and information sciences, such as co-authorship analysis, co-citation analysis, bibliographic coupling, journal mapping, give the researcher the opportunity to extract from bibliographic datasets some overall insights on a certain research field or topic, thus observing its social or intellectual structure as well as its knowledge spaces, identifying key authors, seminal papers, research areas and influences, historical trends of topics, etc. All this data are often displayed in a series of maps or data visualizations that allows the user to explore data in order to get a more detailed and fine-grained picture of some specific aspects of the mapped knowledge field.

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This approach can be extended to the field of Design Research in order to give design scholars and students some maps and tools from which obtaining insights about the field, quickly identifying key authors or papers, discovering main research branches or groups, explore geographical or historical patterns of topics. In this work we provide a visual exploration of Design Research academic publications with a number of network maps that explore different aspects of the field.

2. Mapping Knowledge domains - Scientometrics and bibliometric mapping

Visualizing an entire area of scientific knowledge - or a “knowledge domain” - taking a “big picture” of a field of research or intellectual production could be useful and desirable for a number of reasons (White 1998, Borner, Chen & Boyack. 2003).

Traditional approaches for exploring research domains such as state of the art or literature reviews, while of course keeping intact their value, could be very difficult to kickoff as scholars, especially those facing research in new fields or topics, have to browse through tons of papers to start grasping some insight or identifying key works or authors to take into account.

Disciplines and methodologies as Scientometrics, Bibliometrics, and Citation Analysis developed a large set of techniques and tools to face this kind of issues. Starting from the seminal work of scholars as Garfield (Garfield 1955), who laid down the foundation for the creation of citation index databases, bibliometrics and scientometrics has developed techniques to extract from this databases informations about the structure, the topics and the dynamics of entire knowledge domains (Borner 2003).

The starting point is the assumption that the act of referencing some author’s work in a paper is sign of some sort of semantic relationship between the two works. If we expand our observation from the single reference to the system of references that exist between a large number of papers and books, bibliometric networks and clusters of authors and documents start to emerge, revealing structures that could be hidden at a first glance into the field.

A bibliometric network is a system of interrelated nodes and edges. Main types of nodes are papers, journals, authors, or keywords, while edges express relationships between pairs of nodes. The most common relations that are analyzed are citation links, keyword co-occurrence relations, and co-authorship relations (van Eck, Waltman 2014).

As already discussed by Borner, Chen & Boyack in an extensive overview of the field there are different approaches to knowledge domain mapping. For instance there are author-based maps, where authors are the nodes and the type of relation can be of two types: author co-citation (Chen, Paul, & O’Keefe, 2001; Ding, Chowdhury, & Foo, 1999; Lin & Kaid, 2000; White & McCain, 1998) that typically reveals the intellectual structure of a field; co-authorship, or collaboration network, that show the social network of a research field (Luukkonen, Tijssen, Persson, and Sivertsen 1993). Another type of co-citation analysis is explored in maps where nodes are not authors or documents but academic journals (Leydesdorff, de Moya-Anegón & Guerrero-Bote 2010)

Another type of maps are based on co-word analyses, that could be used to explore the cognitive or semantic structure of a field (Callon, Law, and Rip 1986, Peters and Van Raan 1993).

3. Mapping Design Research Field

So far no other studies have applied scientometric or bibliometric mapping techniques to the field of academic Design Research in order to develop knowledge domain maps or networks. Previous studies in the field of Design that implemented bibliometric methodologies based on the extraction of data from citation database as ISI Web of Science are mainly concerned in defining performance metrics, ranking and impact of journals and publications (Gemser, de Bont, Hekkert & Friedman, 2012, Gemser, de Bont 2016).

The field itself present several issues with this approach due to a number of reasons. For instance the fact that the output of design research and key performance indicators are not limited to papers published on academic journals: there are many kinds of valuable output from design research such as presentations, artifacts, patents, catalogues as well as exhibitions, projects or awards received (Gemser, de Bont 2016).

Another issue is that bibliometrics and scientometric mapping methodologies relies entirely on data stored in international scholar databases such as Elsevier Scopus or Thomson Reuters ISI Web of Science and key design publications are often not well covered inside those repositories.

In addition to this it is not simple to identify a core list of design publications and venues as a starting point for the collection of bibliometrics data, as the field of Design Research reveals a strong interdisciplinary structure, as stated by Gemser et al. “design researchers address design topics from the perspectives of different foundational disciplines, including engineering, psychology, anthropology, sociology, arts, management, computing, information science, economics, and more.” (Gemser, de Bont, Hekkert & Friedman, 2012).

Nonetheless a wide enough collection of publication can be identified on the above mentioned repositories and it is interesting to explore the citation patterns that emerge from the analysis and to observe the bibliometrics networks and maps that emerge.

The key question here is to identify a set of publication that are relevant for the design academic community and from which extract citation data. Friedman (2008) made a first extensive study attempting to provide a long list of design related publications drawing from a large number of sub-fields. More recent studies (Gemser, de Bont 2016) identified a list of what we can call core design research publications that are perceived as central by the international academic community and that at the same time are indexed under ISI WoS or Scopus.

For the present study we rely on the list provided by this studies and focus our attention on those journals that Gemser et al. define as “design-focused” publication (as distinguished by “design-related” publications) and that constitute the core of design research academic publications. The list of core design academic journal include the following six publications: *Design Studies*, *Design Issues*, *Journal of Engineering Design*, *The Design Journal*, *International Journal of Design*, *Journal of Design Research*.

4. Data collection and processing

We built a dataset downloading all the citation data related to major design research journals from the Scopus online repository. As Scopus data are not exhaustive for some key publications before the

year 2005 we limited the timespan of the collected papers for this study between 2005-2016. As a result we collected 1662 papers divided as follows.

Table 1. Design Journals

Journals:	N. of Articles
Design Issues	348
Design Studies	314
Journal of Engineering Design	373
The Design Journal	225
International Journal of Design	203
Journal of Design Research	199

The dataset includes publication metadata such as title, authors, year of publication, institutions, keywords, DOI, and above all the complete list of all cited references for each article. This way we collect a list of several thousands of cited works that constitute the overall domain of intellectual references that the authors of the collected papers express.

On the resulting dataset we performed a number of data pre-processing and analysis routines in order to extract from the collected papers and their references a series of networks visualization that could help exploring this knowledge domain. Mainly we used some well known tools and procedures for scientometric mapping such as VOSviewer, SCI2 for the extraction of networks and Gephi and ScienceScape for refinement and data-visualization.

We focused our attention on different type of networks emerging from the data: co-authorship network (Luukkonen, Tijssen, Persson, and Sivertsen 1993), journal and author co-citation networks (Marshakova, 1973; Small, 1973) and keyword co-occurrence network (Callon, Law, and Rip 1986).

5. Data visualization and maps

In the following section we present pictures and maps as output of the data analysis. Each section contains a different view on the dataset related to the unit of analysis and techniques applied for the extraction of the network. All the pictures are screenshots of interactive visualization (that allows the user to zoom, filter and select specific areas of the graph) built in Gephi and exported as dynamic graphs in Sigma.

5.1 Journal and Source Maps

Journal maps are the result of different techniques. Generally speaking this kind of maps provide a wide overview on the dataset and on the social and intellectual structure of the selected sample of publications.

The first two maps fig.1 and fig.2 are extracted using the SciencePo Medialab tool ScienceScape and then refined with Gephi. Fig. 1 depicts a bi-partite graph in which we have two types of nodes, author and journals, and edges are drawn between authors and journals when an author has at least two published article on that venue. What is clearly depicted are the different communities of

authors around the journals with some interesting overlapping between them. At the center of the picture there are those transversal authors that publish on three or more journals.

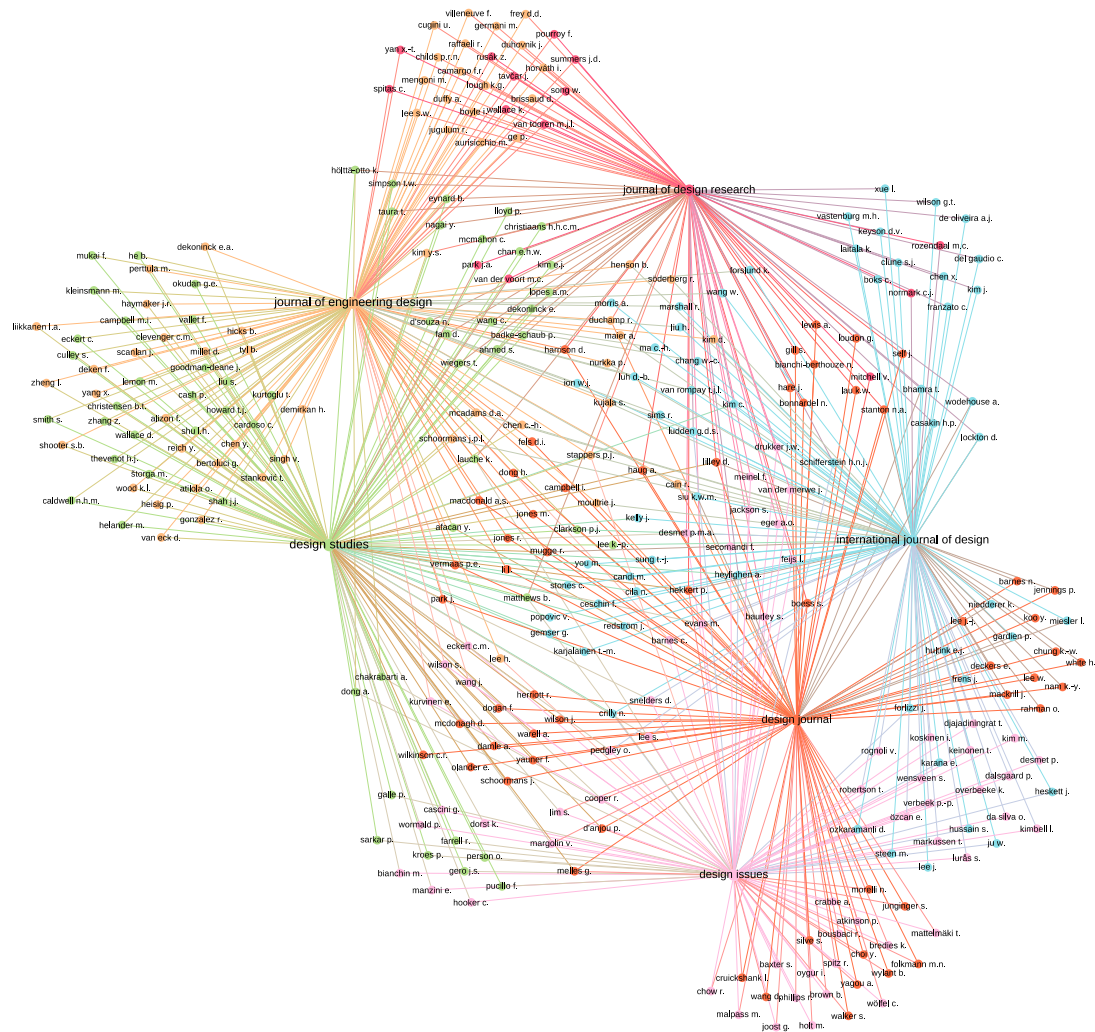


Figure 1. Journal-Authors Map.

In fig.2 a different network shows the relationship between journals and most relevant article keywords. *Design Issues* is not included in this picture because Scopus database do not provide

article keywords for that specific journal. As in the former example, this is a bipartite graph in which two types of nodes, keywords and journals are linked when a keyword appears at least three times in that specific venues. On the borders of the pictures we can find journal specific keyword, while at the center there are a number of domain keywords that are widely used across all journals.

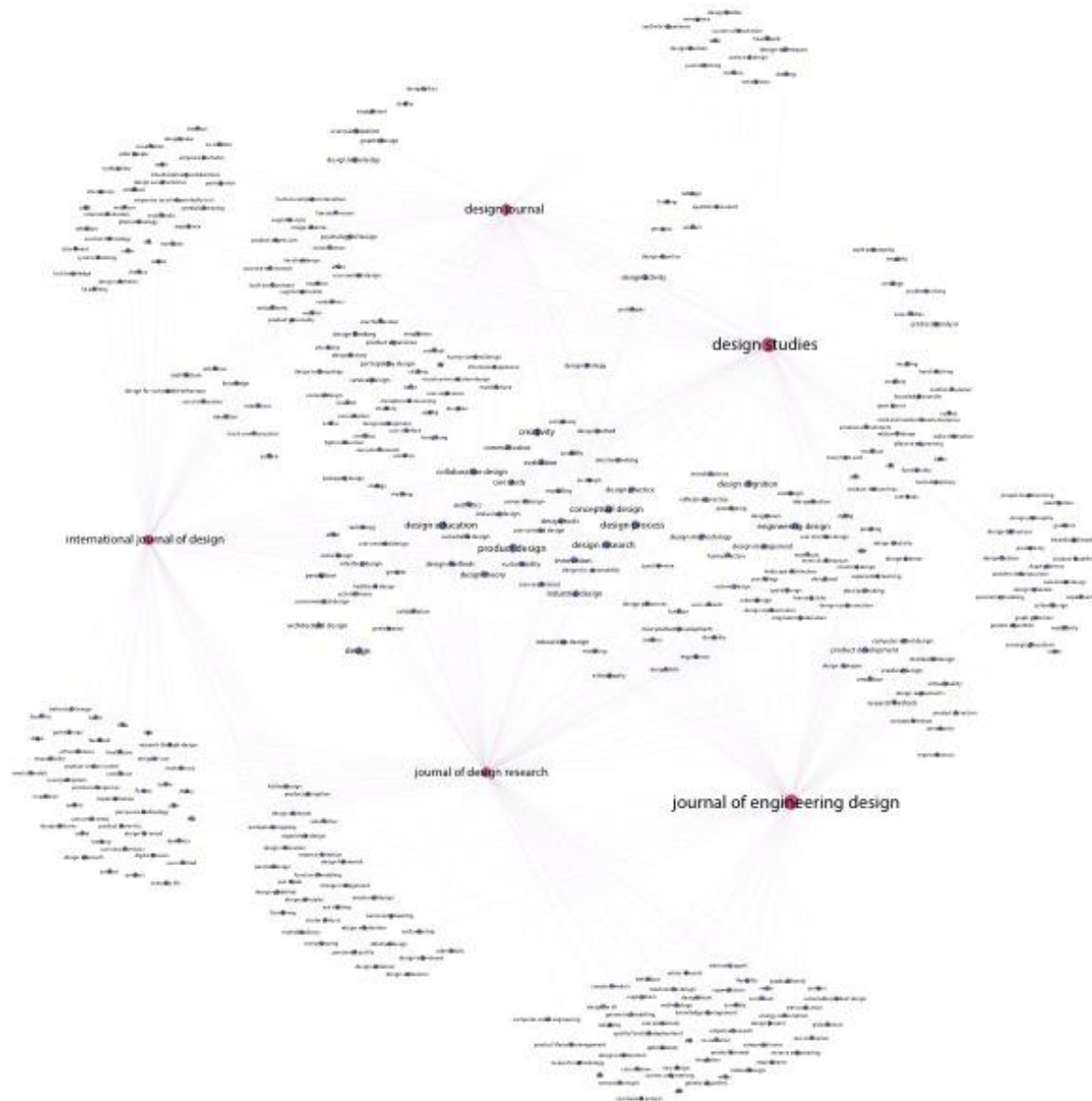


Figure 2. Journal-Keywords Map

A third map (fig. 3) depicts the extended field of journals and sources related to this field of research. The map is the result of a co-citation analysis with journals chosen as unit of analysis. As well explained by van Eck & Waltman, two publications are co-cited if there is a third publication that cites both publications (van Eck & Waltman, 2014, Marshakova, 1973; Small, 1973). This map shows journals and sources (books, papers, etc.) that are included in the references of the papers published by the six design journals chosen as starting point for this analysis. Two sources are linked if they contain articles that are both cited by a third article. Co-citation is considered by scientometric

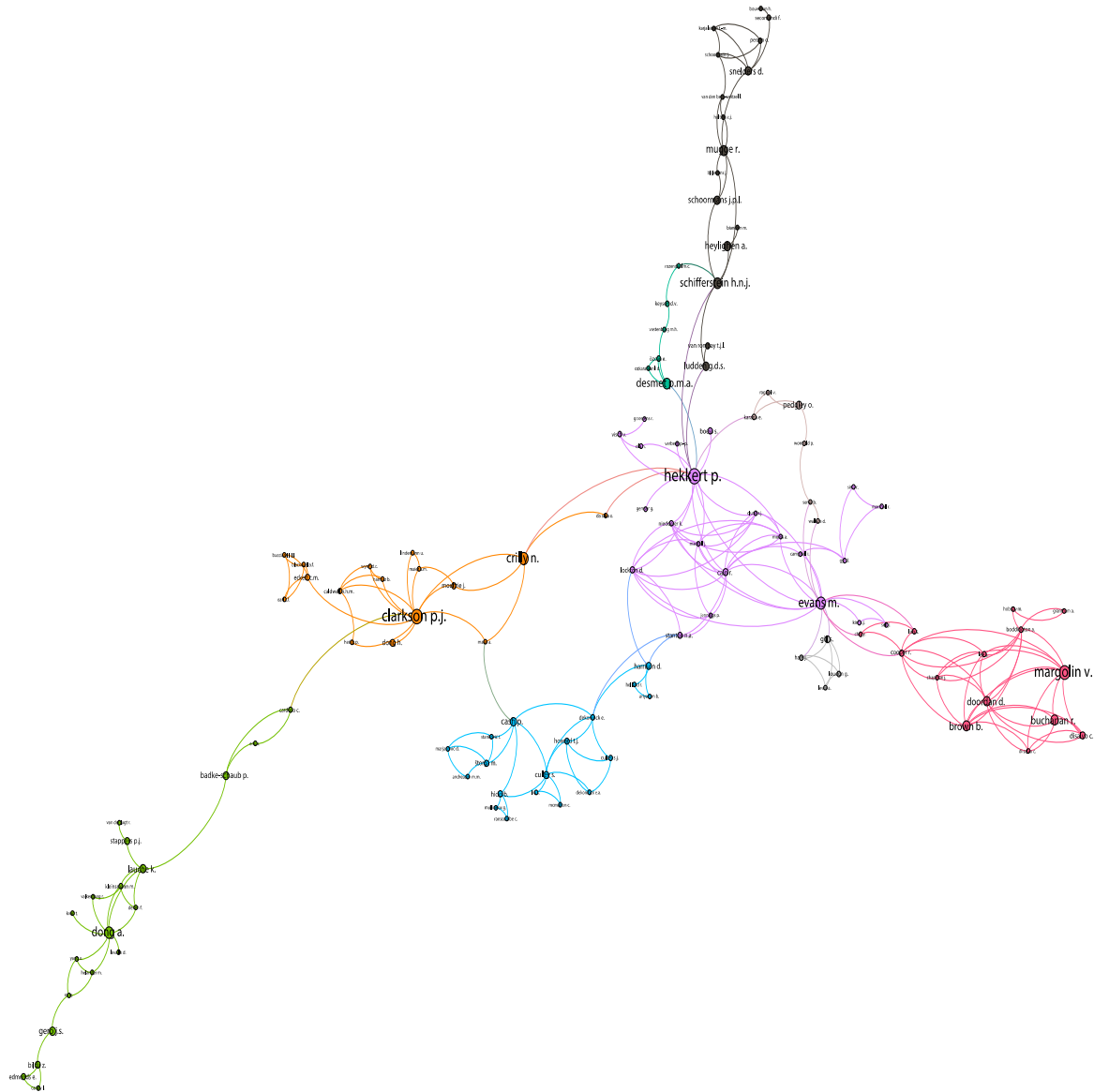


Figure 4. Co-Autorship Map

The map in fig.5 shows the co-citation network of the authors which work received at least 15 citations. Nodes represent authors; links are drawn when two authors are both cited by a third source. The size of the node is related to their In-Degree value, or the number of incoming links. Colors of nodes and links is obtained with the Modularity-class value measured with Gephi and depicts groups of authors that are most likely cited together in a large number of publications.

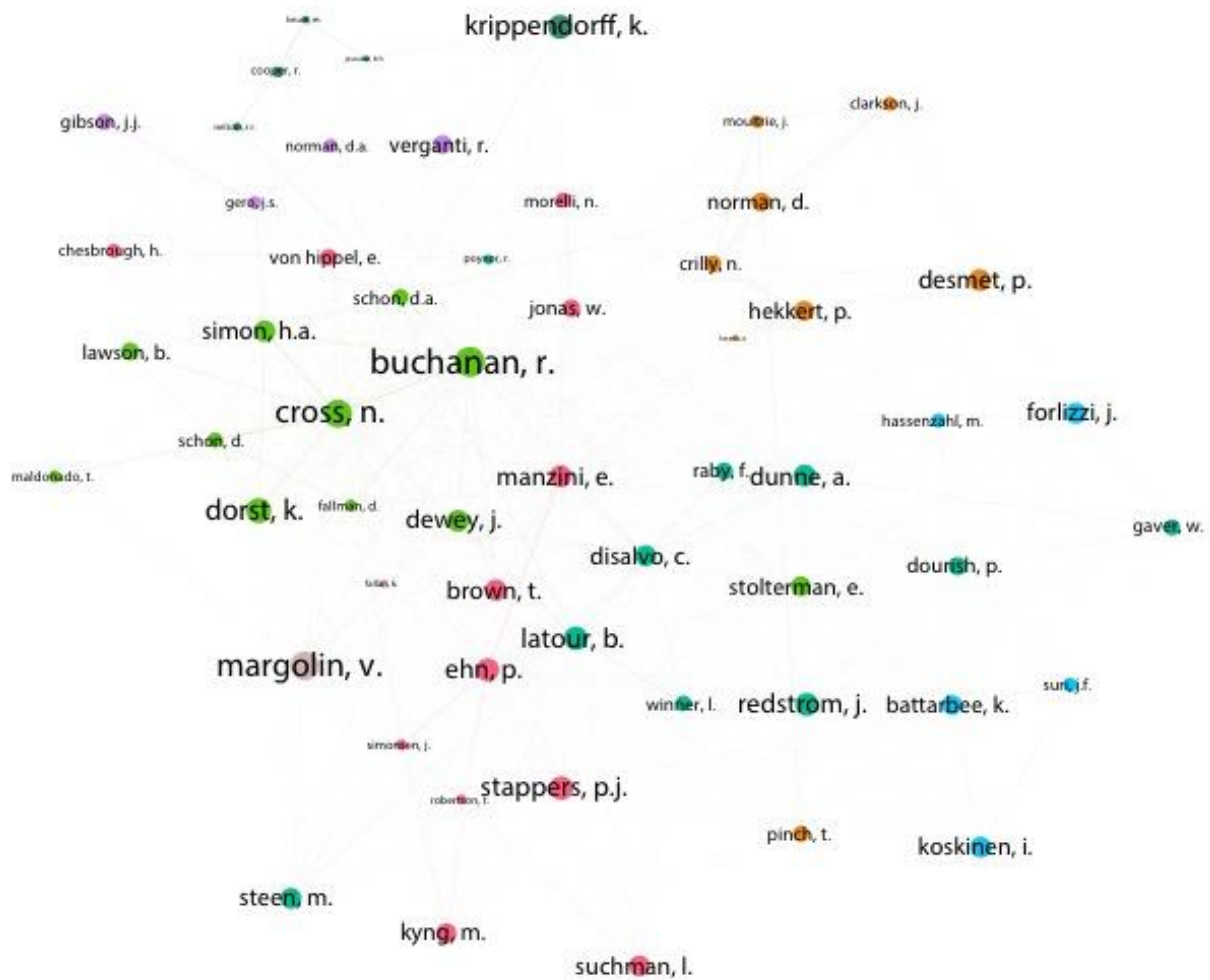


Figure 6. Author Co-Citation Map

5.3 Document Map

The map (fig. 6) is a screenshot of an interactive map showing another type of co-citation network. This network is built using single documents or papers that received at least 20 citations as unit of analysis. Each work is a node and is linked to other nodes according the number and the strength of their co-citation. From this map emerge clear groups interrelated documents that represent clusters of intellectual elaboration and thematic exploration with some prominent documents at the center of the pictures that are hubs interconnecting different areas or sub-domains of research.

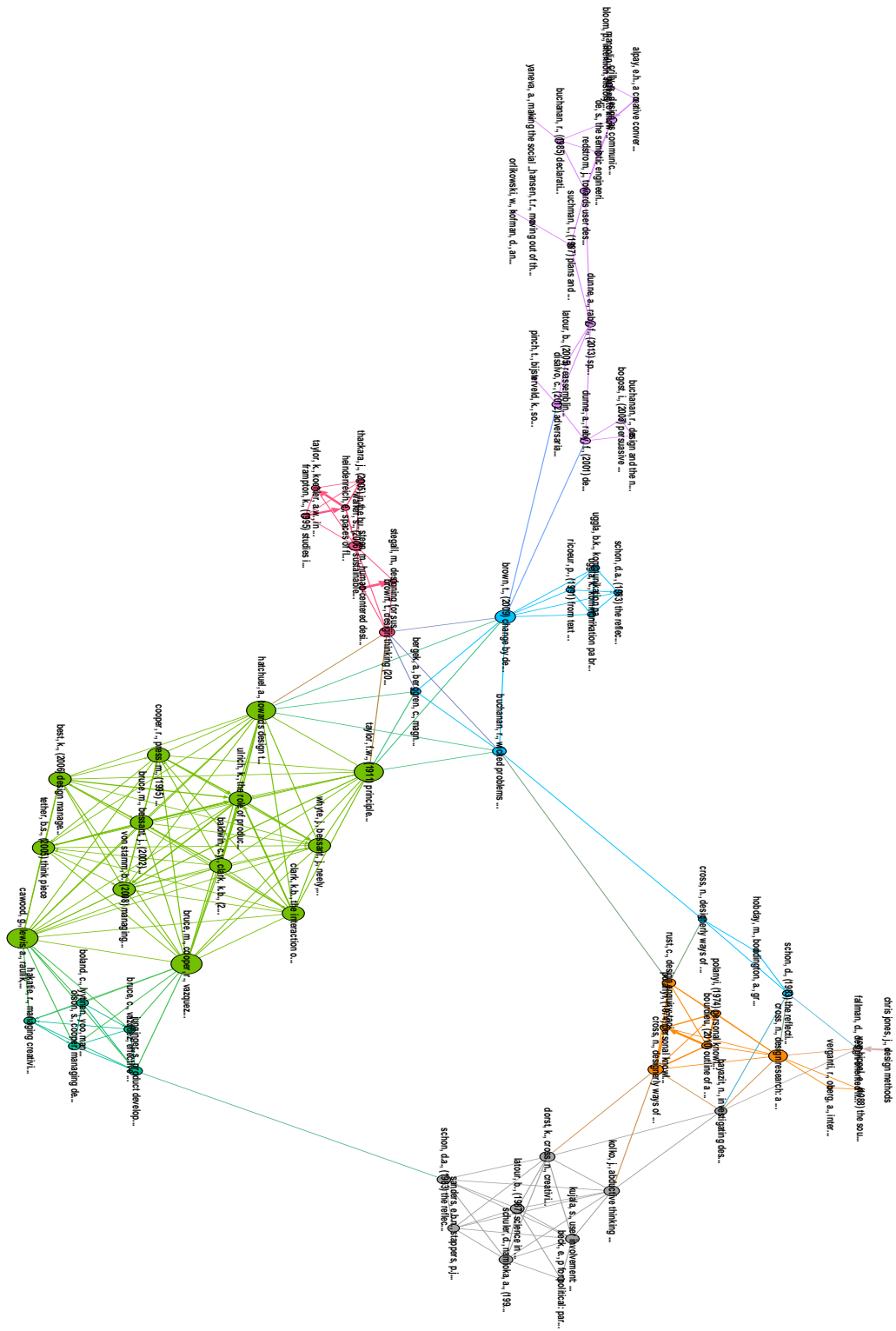


Figure 6. Document Co-Citation Map

5.4 Keywords Map

Also the last map (fig. 7) is a screenshot of an interactive map showing a co-occurrence network of interrelated keywords. The nodes are keywords that appears at least 3 times in the sample of papers we analyzed. Two keywords are linked if they appear together in the author-keyword field of Scopus

could be useful to explore the field in a different way from the account provided by more traditional literature reviews and surveys of the field.

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