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The functional anatomy of science mapping

Katy Börner: Atlas of science: visualizing what we know. The MIT Press, Cambridge, MA/London, UK, 2010, US$20

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The "Atlas of Science" by Katy Börner is a truly impressive work. The title of the book is somewhat misleading: as being both a comprehensive overview on the history and developments of science mapping (SM), and a unique collection of science maps, the title would rather be an "Atlas of Science Mapping". The relevance of such a distinction is becoming obvious when one is to find the place of this volume within the specialty: for the scientometrician, the title recalls an initiative of Eugene Garfield, launched by the ISI a few decades ago, called the "ISI Atlas of Science". This series, relatively short-lived, aimed at the visualization and evaluation of scientific fields in a periodic and systematic manner. To this end, a specific mapping technique, co-citation analysis was utilized. As such, the ISI Atlas of Science is related to Börner's book as an example of science maps and mapping methods, and, indeed, included in the overview as a milestone of the story exposed.

According to the author, the book is the accompanying material of, and should be viewed as being in unity with an exhibition of science maps, presented in multiple ways (included in the book, organized as a virtual and a physical exhibit, too).[1] In this setting, a main role for this large volume is suggested to be explanatory: it serves as a guide to the understanding of what SM is about. The explanations of Börner, as we shall see, fill in several, usually neglected gaps in the usual discourse of science mapping.

The most striking feature of the book is the scope of the approach. In making the inventory of SM, a very diverse group of mapping exercises have been covered, representing practically the full range of classical and recent kinds of maps and mapping methods.

At one extreme, we can find e.g. the the global map of scientific paradigms by Klavans and Boyack (p. 136), as the most granular reference system of the scientific landscape to date, generated by processing the references of (almost) each single document indexed in the SCOPUS database (and, in some versions, in the ISI databases as well). This mapping also illustrates the business use of SM, since, as pointed out by Börner as well, it enables

[1] http://scimaps.org/flat/exhibitions/.

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actors of science to evaluate their own position and opportunities in the market of science and technology production. Indeed, lately, the SCOPUS paradigm map provided the basis for a commercial toolkit developed by Elsevier, offered for strategic planning to various actors of S&T (SciVal Spotlight).

On the other extreme, one can study the work of Daniel Zeller, called the "Hypothetical model of the evolution of science". Zeller is, as the biography reveals, primarily an artist, a sculptor. His work is a metaphor embodied in a sculpture-like visualization: he represents scientific knowledge as a stratified piece of rock ("meteor"), layers accounting for periods in the history of science. The reticular texture of the body of scientific knowledge indicates the pattern of the history and development of fields ("tubes"): their splitting, merging and extinctions are also color-coded. Most interestingly, this visualization apparently inspired Börner when (re)constructing a conceptualization of science, at least at the visual and metaphoric level, in the background of SM as a specialty (see below).

Given this variety, the reader might naturally wonder, whether these are primarily scientific, commercial or aesthetic purposes that science mapping serves? The art/science dichotomy has also been, in several respects, an issue for practitioners as well, as indicated, from the perspective of the scientometrician, by a quotation found on Börner's website herself, in relation to a workshop on SM in 2007: "We need insight instead of eye candy".[2] The answer to this sort of questions is very convincingly given by the taxonomy imposed on, or, rather, a "functional anatomy" of science mapping, made explicit in the book. It can be learned that building a data-driven, empirically informed reference system for evaluation purposes, uncovering dynamics of innovation or the evolution of scientific communities, identifying research fronts, or visualizing the content of bibliographic databases and, ultimately, the (self-) organization of science as of today is almost inevitable for research funding agencies, policy makers, scientists, science administrators, and educators, respectively. So, eventually, as Börner says "These maps are not designed to be eye candy; they are designed to convey information" (Matson 2010). At the same time, the interplay between the scientific and the aesthetic dimension of maps makes them more tangible and accessible to the general public, and, nonetheless, gives way to present them in the form of an exhibition.

A remarkable, though somewhat implicit feature of the book is the contextualization of science maps. The "Atlas of science" introduces the enterprise of science mapping by a chapter titled "Towards the science of science", as reflecting primarily Price's ideas, that starts with a systematic conceptualization of science. In this model, science is conceived as scientific knowledge accumulated through its history. According to this "paleontologic" representation, this body of knowledge has a rich inner structure: it is stratified by time periods, the most recent developments constituting the surface, or "epidermis". Knowledge accumulation is not to be confused with an accumulative nature attributed to science (long disqualified by the philosophy of science). On the contrary, the structure preserves the phylogeny of scientific specialties, splitting, merging or extinction of fields or paradigms being observable as a "tubular" pattern in its texture. The metaphor is made operational by modelling scientific knowledge with the artifacts or "units" of scientific output (publications, journals, software etc.), whereby the patterns are instantiated by different relations of these artifacts.

This conceptualization seems to be very useful to accommodate the backbone of science mapping. In this setting, global maps of science, for example, provide us with the structure of the top layers, being cross-sectional snapshots of scientific knowledge. Garfield's

[2] http://ella.slis.indiana.edu/~katy/.

algorithmic historiograms, or citation flow maps, on the other hand, utilize the linkages that cross the (temporal) strata of this big corpus, connecting different layers. Research front detection addresses the epidermis, the most recent patterns developed in the evolution of science.

An additional choice, also truly helpful when conveying the nature of science mapping, is the emphasis on relations. The focus of the above conceptualization, after presenting the visual metaphor and its operational version, is a basic taxonomy of utilizable relations and network types of documents, serving as proxies for the structure of knowledge. Direct and indirect linkages between documents, authors or other units are discussed here, such as citation (direct), co-citation or common references (indirect). In this way, the differentia specifica of science mapping is exposed: whereby bibliometrics or scientometrics is an underspecification in many cases, dealing with the relational information encoded in scholarly output is what distinguishes science mapping from other statistical methodologies applied to science.

In sum, what makes this exposition of science mapping special, is that Börner explicates what might be termed a theory for science mapping. This theory connects an appropriate conceptualization of science with an empirical methodology for its exploration. In this respect, it might be of interest to compare Börner's approach with a similar book from Chaomei Chen, published in 2003 (Chen 2003). The agenda of "Mapping Scientific Frontiers" was quite similar to that of the "Atlas of Science". Indeed, the two expositions of the field have many features in common. Both approaches start with an extended history of the field, rooting this specialty, among others, in the history of mapmaking. Shared among these authors, also, is a comprehensive overview on the development and achievements of science mapping. On the other hand, the emphasis in Chen's volume seems to be put on a detailed explanation of infoscience methods applied for knowledge visualization. Consequently, "Mapping Scientific Frontiers" exposes science mapping as a branch of information science applied to a specific domain. From the perspective and discussion of Börner, SM is conceived rather as an interdisciplinary specialty on its own right, incorporating insights from science studies, and utilizing techniques from information science.

Science maps themselves also play a somewhat different role in the two presentations. The methodology-oriented approach of Chen demonstrated the techniques in a couple of very detailed case studies, primarily of interest for the scholarly community. Börner, on the contrary, organized her book around the exhibition of maps, addressing a wide range of actors, including researchers, policy makers, educators etc. The exhibit conveys methodology and results in a well-balanced manner.

It should be noted, however, that maintaining this balance between method and result throughout the whole volume poses a challenge for the articulation of details necessary and sufficient for understanding. The author makes an impressing effort to guide the reader, not supposed to be an expert herself, through the field from the basics (nature of science, nature of bibliographic data, use of databases etc.) to sophisticated techniques such as paradigm mapping. At the same time, even in the introductory chapters, the lexicon used, in several places of the text, requires the reader to be familiar with scientific, or even info- and computer science terminology. Examples are the concise descriptions of the "laws" of science dynamics, such as power-law-like distributions characteristic of the behavior of the scientific literature in several respects. Referring to distribution tails, log–log plots and further mathematical constructs (such as different types of matrices elsewhere), being nevertheless part of the scientometrician's everyday jargon, might be demanding for some sectors of the target audience.

This last observation leads us to the probably most intriguing question: from this heavy work, both intellectually and literally, who would profit the most? The answer is partially encoded in the structure of the book, called here the "functional anatomy" of science mapping: the enterprise uncovers the value of mapping approaches for science administration, science policy making, strategic planning in R&D, education, just to mention the most salient arenas. The author of this book review, maybe biased being himself a practitioner in science mapping, has a strong impression that representatives of this profession (scientometers, bibliometers) can find massive support in their praxis from the Atlas of Science. Both evaluative approaches, e.g. in need of a reference system of comparable aggregates in science, or descriptive ones, aiming at the exploration of patterns and processes, may heavily utilize this comprehensive inventory. We may not yet possess a consensual reference system for science (though science maps tend to converge), but, as a prerequisite, apparently have a reference work of science mapping. The "Atlas of Science", though certainly not from its size, is the handbook to fulfill this role.

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