Book Review

Atlas of Science: Visualizing What We Know. Katy Börner. Cambridge, MA: MIT Press, 2010. 288 pp. $29.95. (ISBN: 978-0-262-01445-8).

Katy Börner's lavishly constructed *Atlas* is a visually pleasing, scholarly, and informative index of science maps. The book jacket says: "It serves as a sumptuous visual index to the evolution of modern science and as an introduction to 'the science of science.'" Science maps "provide guidance for navigating, understanding, and communicating the dynamic and changing structure of science and technology" (Börner, 2010, p. ix). In other words, they serve as visual representations of scientific data. Within information science, science maps are frequently utilized to illustrate bibliometric analyses visually (White & McCain, 1997). Citing examples in Börner's book from other knowledge domains, science maps are used to understand the impact of air travel on the global spread of infectious disease or to track the patterns of patents issued worldwide.

The book is not meant to serve as a stand-alone resource. It is an accompaniment to a physical exhibition called *Places & Spaces: Mapping Science*; Börner is the curator. The exhibition is planned to last 10 years (2005–2014), with 10 new maps added per year, and with each year's iteration focusing on a different aspect of science maps. The *Atlas* includes all the maps from the first three iterations: The Power of Maps (2005), The Power of Reference Systems (2006), and The Power of Forecasts (2007). The book's companion website, www.scimaps.org/atlas, provides more information about the exhibition as well as images and associated credits of all maps in the exhibition. At the time of this writing, the website features maps through the sixth iteration (2010).

The book's physical appearance is impressive. Even at an accessible list price of $29.95, the paper and printing qualities are very high, and its attractive presentation rivals many art books. It could almost serve as a coffee table book, but its textual and visual contents are intellectually demanding and rigorous. Weighing over 2 kilograms, and measuring 33×28 centimeters, it is more suitable for a bookshelf than a backpack. Despite the book's substantial size, the maps still appear quite small because of the amount of data they provide. Nonetheless, it is important to remember that the book serves primarily as an index as well as a contextualization resource for science and science maps. To see a full-size version of a map—and, perhaps, to comprehend the information presented in a map— the reader may need to visit the exhibition in person or purchase a 60×72 centimeters print through the website. (Prints cost $35 for an inkjet version, or $75 for an archival-quality version, plus shipping.) All maps can be viewed for free in a high-resolution TIFF format on the website, but some of the more detailed maps still appear too small in size online for significant interaction.

The *Atlas* comprises five parts, with each part containing several double-page spreads that individually address particular concepts or maps. An appropriate quotation introduces each part, which is a minor but enjoyable feature. Part 1, Introduction, sets the stage for modern science and its need for maps, including the considerable growth rates in the world's population, the rapid development of technology, and the ever-increasing need for information creation and use within various groups. Börner (2010, p. 12) positions science maps within cartographic and scientific history: "[h]istorically, science maps were created to navigate, understand, and communicate the structure of scientific knowledge".

The History of Science Maps, part 2, provides a concise but thorough examination of visionaries' work in eight areas crucial to science map development, many of them with connections to library and information science. These areas, with an example of each, are as follows: Knowledge Collection (Brewster Kahle, founder of the Internet Archive); Encyclopedias (Jimmy Wales, founder of Wikipedia); Knowledge Dissemination (Johannes Gutenberg, inventor of the printing press); Knowledge Classification (Melvil Dewey, creator of the Dewey Decimal Classification); Knowledge Interlinkage (Eugene Garfield, creator of many citation indices); Knowledge Visualization (Edward Tufte, a leader in effective information visualization techniques); Man-Machine Symbiosis (Vannevar Bush, author of "As we may think"); and Global Brain (H.G. Wells, best known for his works of science fiction). Börner's thoughtfully constructed groupings provide a fresh perspective on the contributions of these and other luminaries.

Part 2 also includes a 21-page visual and textual timeline featuring "major advances in the Algorithms, Visualizations, Tools and Books that aim to increase our understanding of the inner workings of science and technology" (Börner, 2010, p. 26). Examples covering the time span from 1930 to 2007 are as follows: Algorithms such as McCain's Journal Cocitation Mapping; Visualizations such as White and Griffith's First Map of Cocited Authors: Starburst Metaphor; Tools such as Leydesdorff's Science and Technology Dynamics Toolbox; and Books such as Chen's *Mapping Scientific Frontiers*. The timeline presents a wealth of information succinctly and makes it easy for the reader to follow the rapid development of science maps, especially in terms of research, methodological sophistication, and computing capabilities.

Toward a Science of Science, the third part of the book, offers an overview of the various methods used to map science. The author's discussion of the related processes seems (perhaps necessarily) complex; it follows the creation of a science map from user needs analysis and scientific conceptualizations to data acquisition, manipulation, and visualization. It is possible to conclude from this section that science map creation methods may still be in their infancy, but method development is a current area of research; see Klavans and Boyack (2011) for an example. The author asks important questions related to the potential of online dataset sharing among scientists, for example, how might such a data sharing system work, especially within a socially driven, cloud-based Internet environment?

Science Maps in Action is the book's longest part, comprising almost half of its pages, and provides the visual index to the associated *Places & Spaces: Mapping Science* exhibition. It introduces various features of the exhibit, but primarily focuses on presenting the 30 maps featured in the exhibit's first three iterations. One double-page spread is dedicated to each geographic map: one page of textual description, and one page for the map. Each science map is presented in four pages: one page of textual description, one page for the map, and two pages for reviewing the map's "data description, analysis technique, reference system, data overlays, and unique features" (Börner, 2010, p. 75). The textual descriptions and explanations are useful, but also somewhat difficult to follow. Speaking from a visual information researcher's perspective, this difficulty is not because of weaknesses in the writing or in the maps themselves, rather it is due to the difficulties inherent in translating between the disparate languages of words and images (O'Connor & Wyatt, 2004), even though words and images elucidate one another (Barthes, 1964; Neal, 2010). Visual depictions of information simply relay messages differently and/or more efficiently than text can, and vice versa.

The first iteration, 2005's The Power of Maps, "demonstrates how maps help us to understand, navigate, and manage both physical places and abstract knowledge spaces" (Börner, 2010, p. 76). These include older geographic maps such as Ptolemy's 1482 Cosmographia World Map, and science maps, including one illustrating 2004 Usenet activity.

The Power of Reference Systems (2006) is the exhibit's second iteration. It "aims to inspire discussion about a common reference system for all existing scholarly knowledge" (Börner, 2010, p. 110). In geographic mapping, a reference system is a coordinate system, but this term takes on new meaning within the context of science mapping. Science map reference system examples in the book include a periodic table of the elements containing an associated visual representation for each element and a visualization of the collective historical edits made to the term "abortion" on Wikipedia. Börner's point suggesting a need for a common reference system is well-taken, given the tremendous variations in the visual representations on each of these maps.

The final exhibition iteration represented in part 4, The Power of Forecasts (2007), "compares and contrasts seismic hazard, economic, resource depletion, and epidemic forecast maps with maps forecasting the structure and evolution of science" (Börner, 2010, p. 145). Examples include The Oil Age: World Oil Production 1859 to 2050 and Maps of Science: Forecasting Large Trends in Science.

Part 5 of the book, The Future of Science Maps, focuses largely on exploring the potential future utility of science maps. The concluding section of this part, Growing a "Global Brain and Heart," while not directly related to science maps, is particularly inspirational: "[t]he subtle human mind faces a flood of information that demands to be processed, managed, and used. There are diverse indicators that a 'global brain' is emerging on this planet" (Börner, 2010, p. 210). The author questions whether humankind's knowledge could be collocated to save Earth's resources.

The References and Credits section at the end of the book is extensive, containing "1,650 citation references, more than 580 image credits, 80 data credits, and 60 software credits" (Börner, 2010, p. 212). It is organized by part and by spread for easy referencing. The list of references is quite useful; students or new researchers in the area will likely find it invaluable. The credits are nicely presented in the book; they also conveniently appear on the companion website with their corresponding maps. The book concludes with an exhaustive index of the subjects and people mentioned.

Börner does an excellent job of reviewing history, examples, and issues related to science maps. An introspective pondering of the well-presented material may lead the reader to ask many questions. Will the extensive preprocessing, design, and implementation work required to produce one science map decrease as computer processing power and a shared understanding of science maps increase? Would the development of a common reference system overcome the learning time required to understand the visual affordances provided in a science map? Although the human brain can process visual information very quickly (Biederman, 1976) and many visualization models are grounded in psychological theories, these facts do not overcome the necessary learning time for understanding the unique reference system provided in every map; the area is simply too new for standard reference systems to exist. Allen Caroll, the Chief Cartographer of the National Geographic Society, noted in the book's Foreword that "there is no equivalent in the cartography of science to the standards and conventions upon which we mappers of the physical world comfortably depend" (Börner, 2010, p. viii).

Related issues bring questions of publication, and how it meets the new challenges of emerging communication modalities, into consideration. As previously noted, the maps contain large amounts of detailed information, and the 33 × 28 centimeters physical book size is an inadequate medium for viewing them. This concern is not limited to print publication; neither a laptop screen nor a mobile computing device would accommodate adequate viewing of these detailed visual documents. How will these spatial challenges be met as visualizations are used more frequently in the future to convey datasets, trace projections, or find and view information in search engines? It seems the disparities in the separate trends toward smaller electronic devices and the level of detail in science maps may need to be addressed before the potential of visual documentation can be fully realized. Cutting edge technologies for visual information, such as the equipment owned by the Renaissance Computing Institute in North Carolina and described by Hayes, Yi, and Villaveces (2009), begin to address the computing needs that may be crucial for developing and using effective information visualization applications.

Ultimately, this book has the potential to increase interest in information visualization and maps of science, and to serve as a useful reference source for people from all levels and areas of science map expertise. Its low price and wealth of attractively presented, engaging material make it a logical choice for many potential buyers, including libraries, information science students and researchers, visual designers, Web developers, and scientists who are considering the utilization of visual methods for sharing and exploring their data. However, those expecting to interact significantly with the maps' contents should be prepared to visit the exhibition in person or purchase a print online. As Börner (n.d.) herself noted: "The main contribution of the *Atlas* might not be the many maps, but the conceptualization of how science evolves dynamically and how it can be measured, mapped, and understood" (¶2).

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