Data Visualization Literacy

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Indiana University, USA

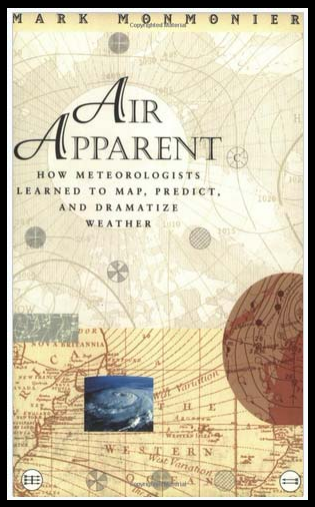
Workshop II: Culture Analytics and User Experience Design
Part of the Long Program on "Culture Analytics"

IPAM, UCLA, Los Angeles, CA

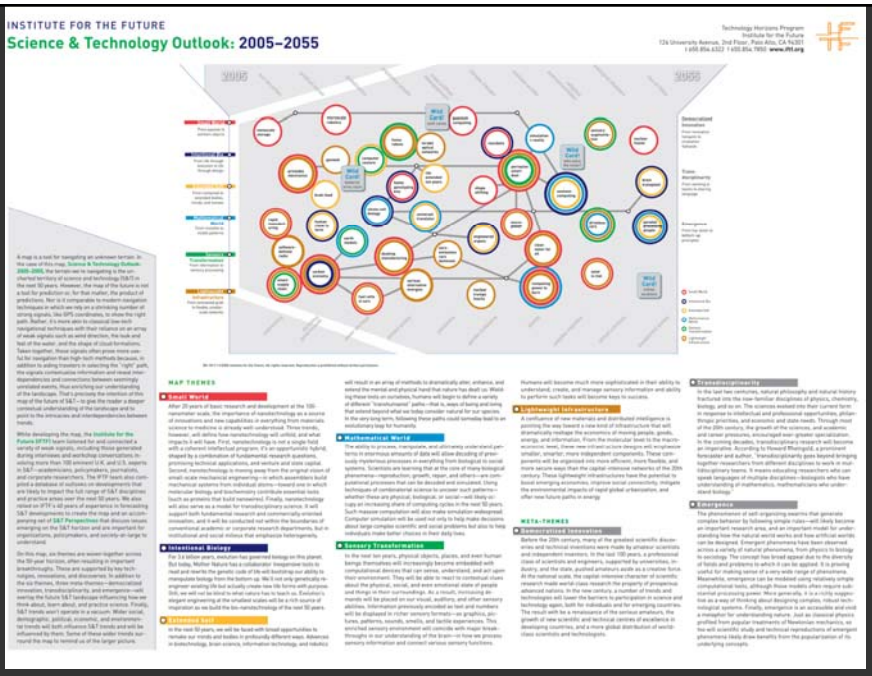
April 11 - 15, 2016

Measuring, Mapping, and Communicating Our Collective Scholarly Knowledge

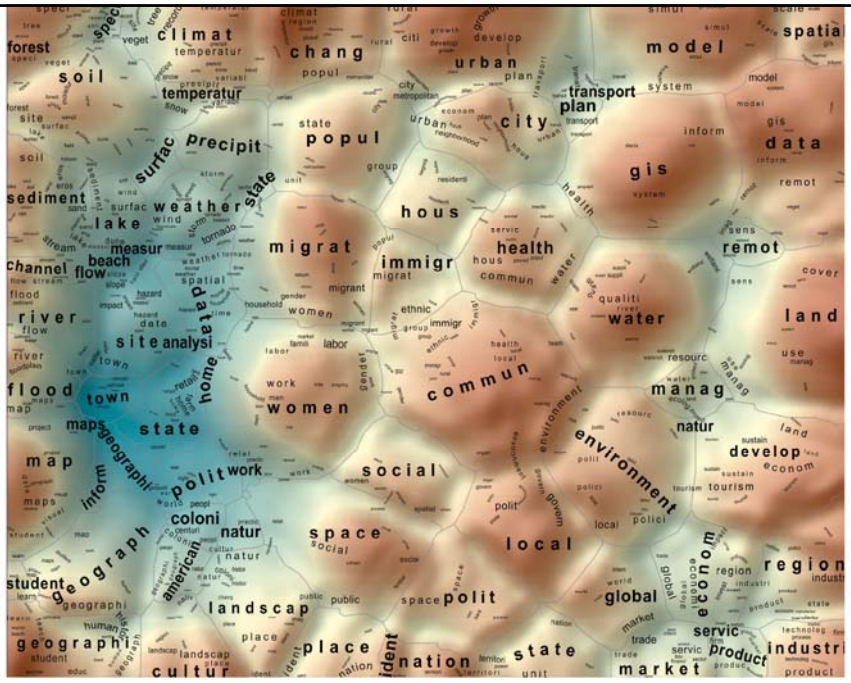
Places & Spaces: Mapping Science
Exhibit



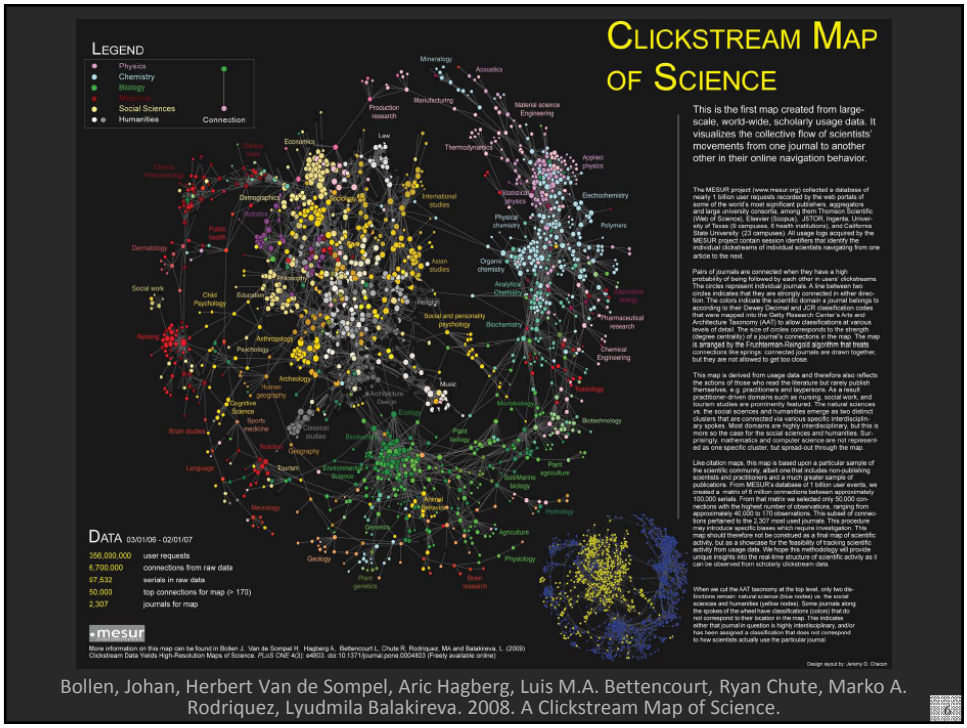
Places & Spaces: Mapping Science Exhibit, online at http://scimaps.org



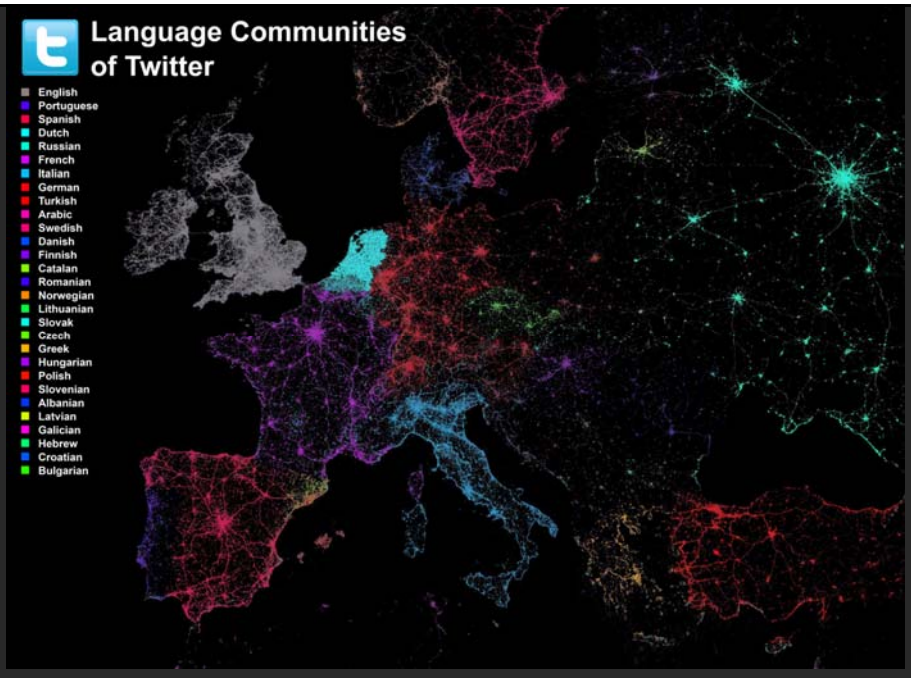
Alex Soojung-Kim Pang, David Pescovitz, Marina Gorbis, Jean Hagan . 2006. *Science & Technology Outlook: 2005-2055*.



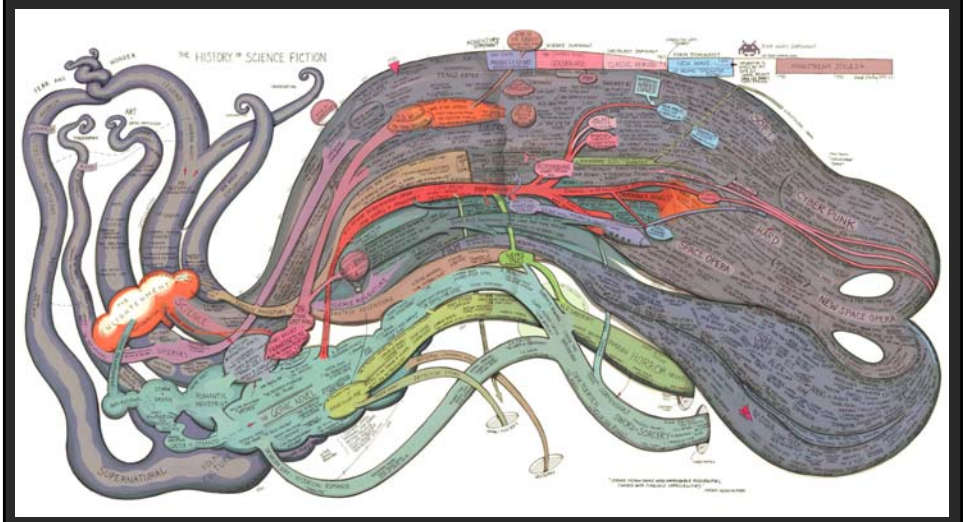
Andre Skupin. 2005. In Terms of Geography.



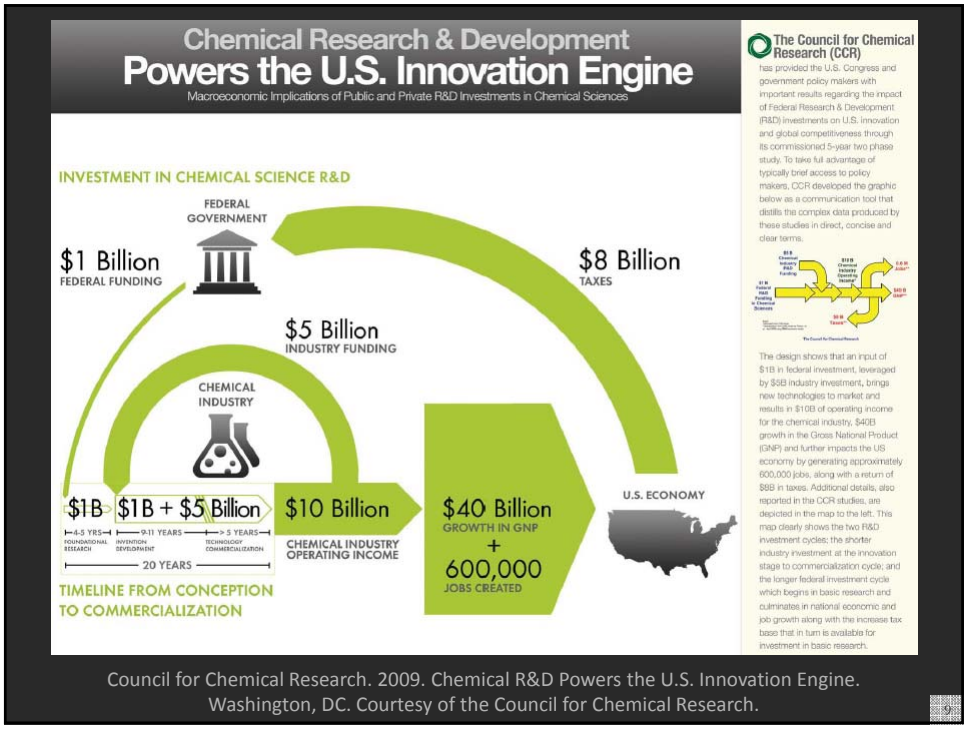
Bollen, Johan, Herbert Van de Sompel, Aric Hagberg, Luis M.A. Bettencourt, Ryan Chute, Marko A. Rodriquez, Lyudmila Balakireva. 2008. A Clickstream Map of Science.



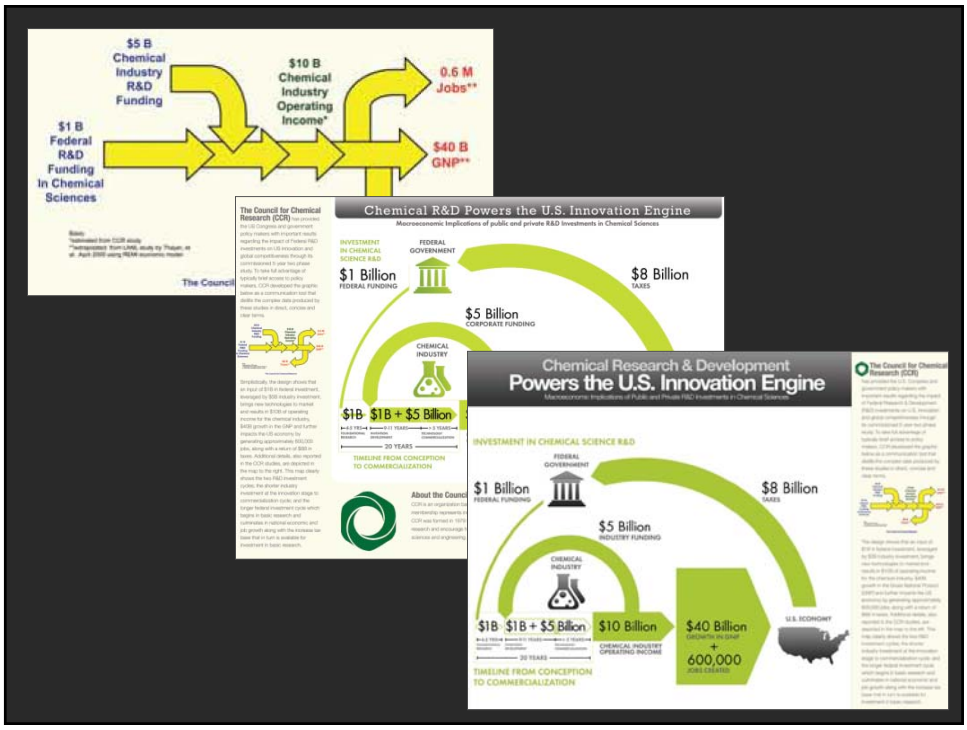
Eric Fischer. 2012. Language Communities of Twitter.



Ward Shelley . 2011. History of Science Fiction.



Council for Chemical Research. 2009. Chemical R&D Powers the U.S. Innovation Engine. Washington, DC. Courtesy of the Council for Chemical Research.



April, 2005: 101st Annual Meeting of the
Association of American Geographer, Denver, Colorado.

2005: 101st Annual Meeting o
American Geographer, Denv

Places & Spaces at Northwestern University
May 14 - September 23, 2015

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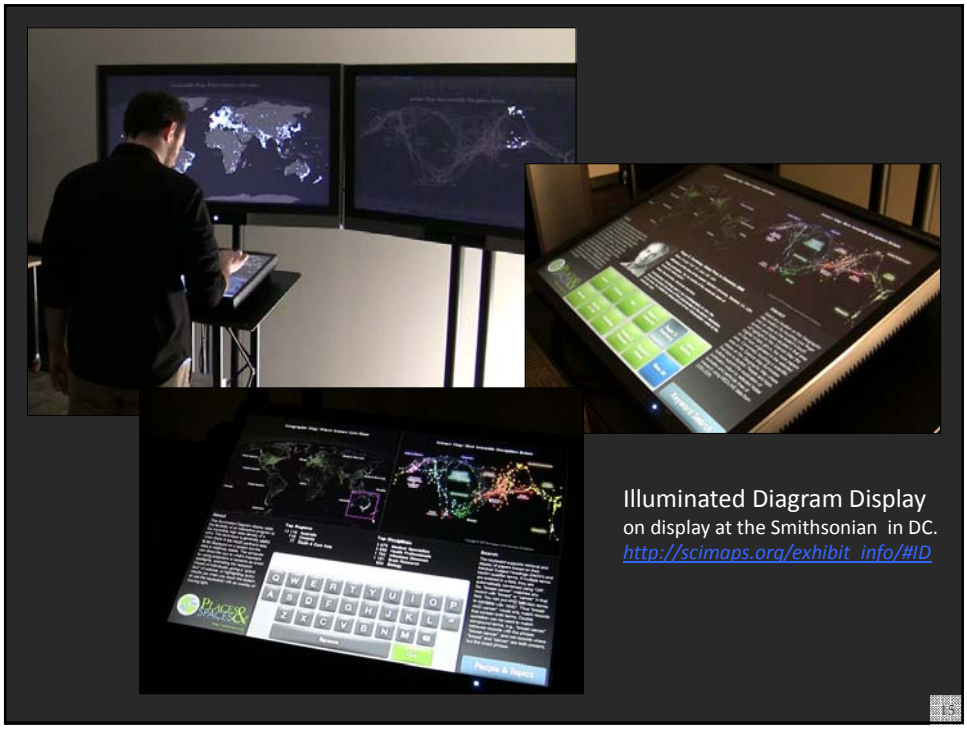

Illuminated Diagram Display
on display at the Smithsonian in DC.
http://scimaps.org/exhibit_info/#ID

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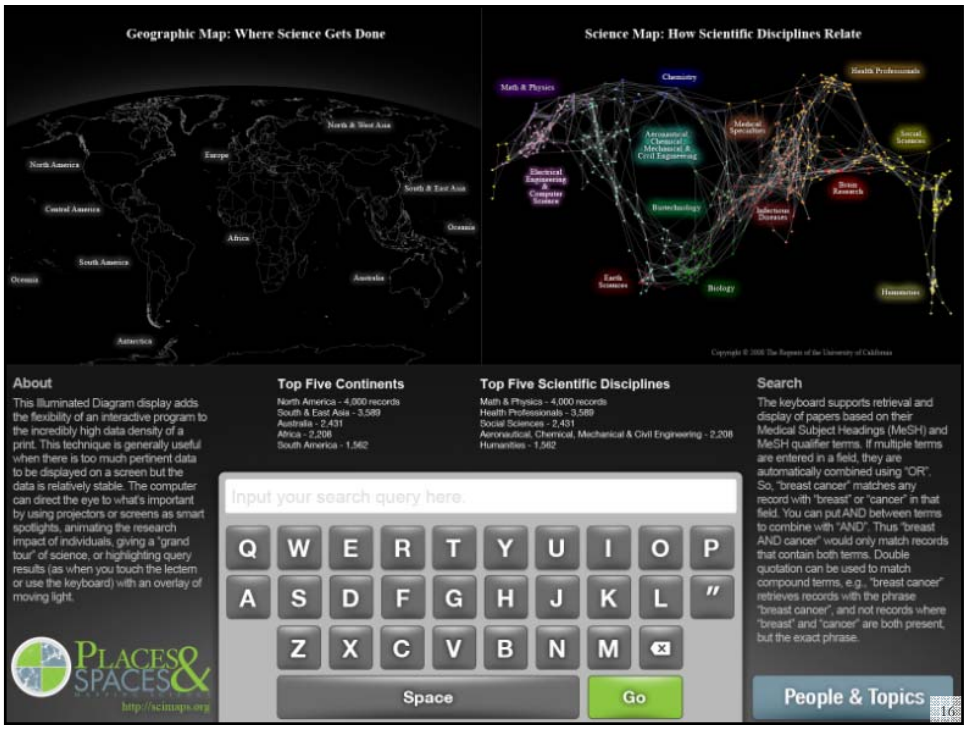

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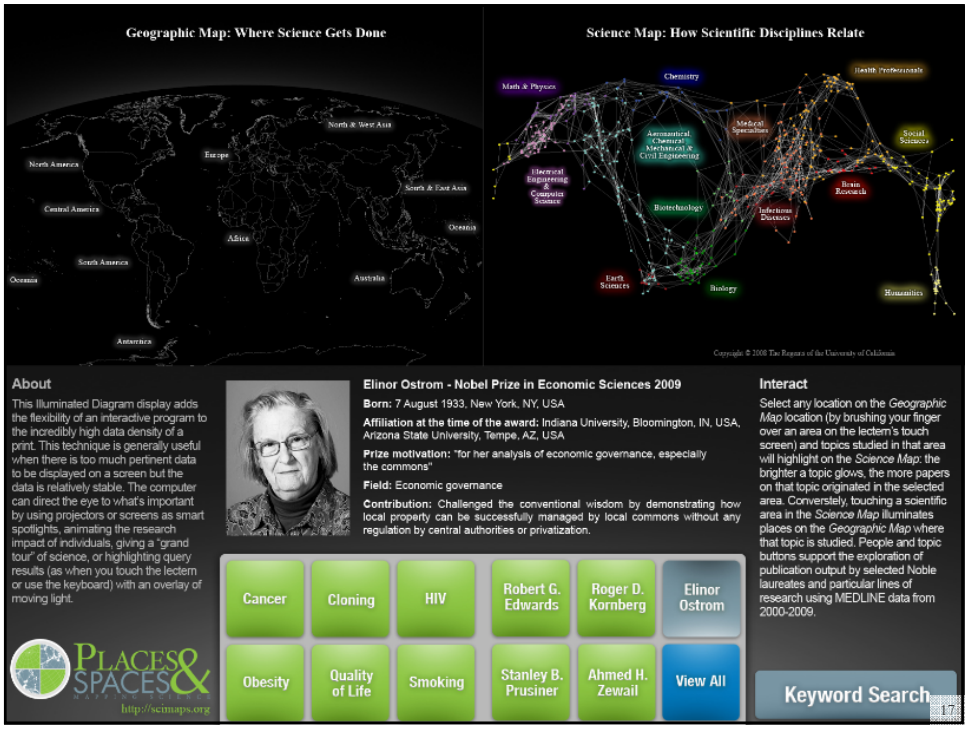

Science Maps in "Expedition Zukunft" science train visited 62 cities in 7 months.
Opening on April 23rd, 2009 by German Chancellor Merkel

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Places & Spaces Exhibit at the David J. Sencer CDC Museum, Atlanta, GA
January 25-June 17, 2016

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Seeing for Action - Using Maps and Graphs to Protect the Public's Health.

CDC Opening Event: Maps of Health
Tutorial and Symposium
February 4-5, 2016

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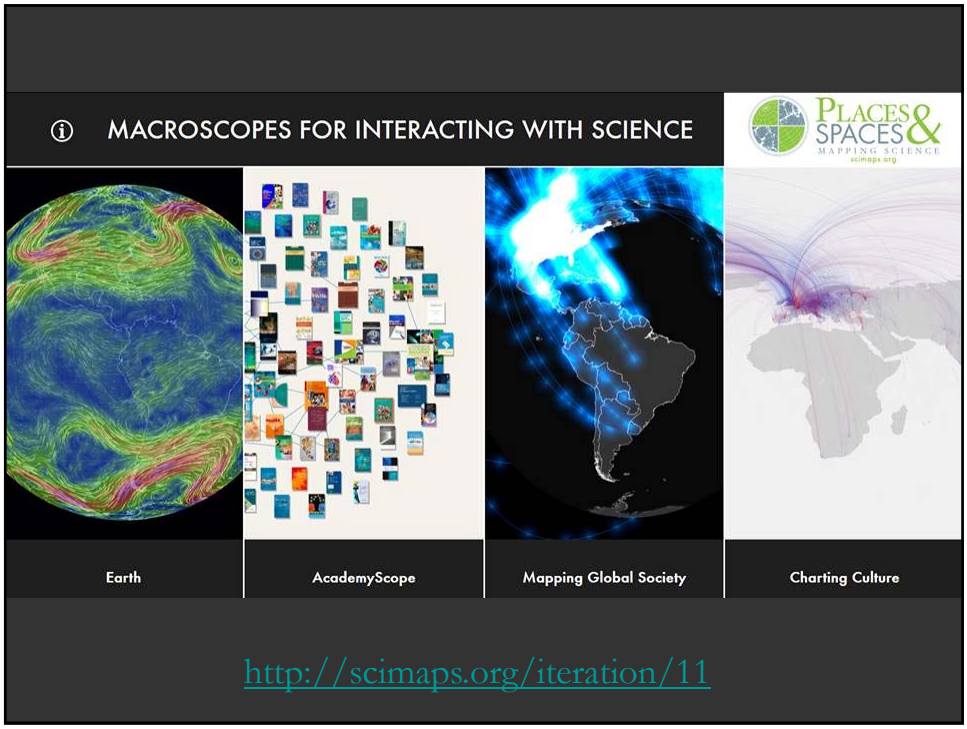
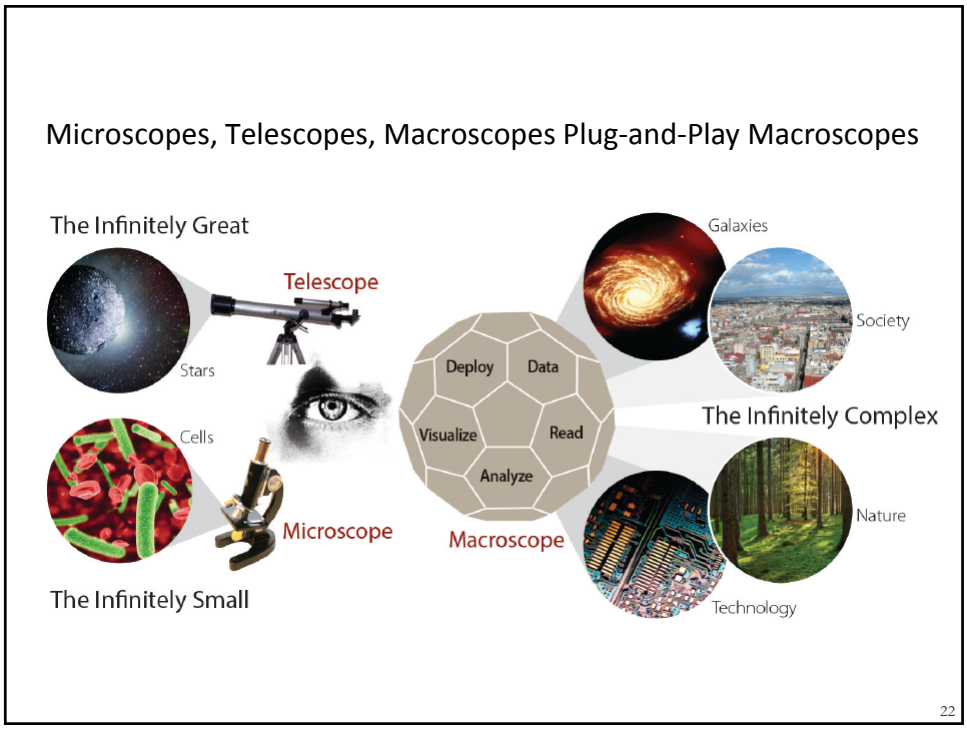
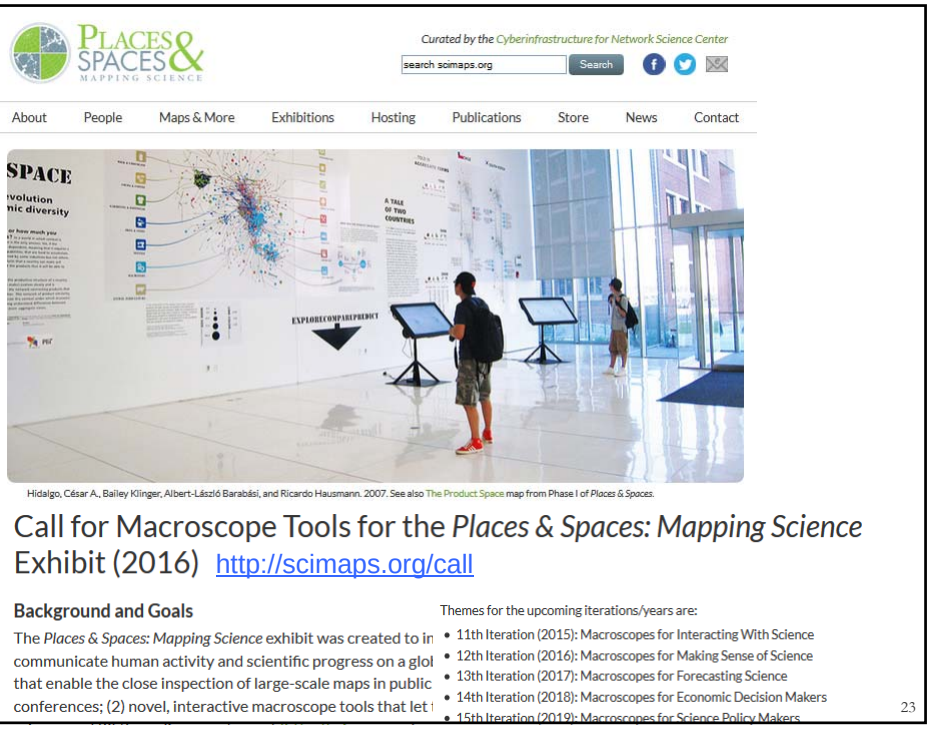

MACROSCOPES FOR INTERACTING WITH SCIENCE
PLACES & SPACES
MAPPING SCIENCE
Earth
AcademyScope
Mapping Global Society
Charting Culture
http://scimaps.org/iteration/11


Microscopes, Telescopes, Macroscopes Plug-and-Play Macroscopes
The Infinitely Great
Telescope
Stars
Cells
Microscope
The Infinitely Small
Deploy
Data
Visualize
Read
Analyze
Macroscope
Galaxies
Society
The Infinitely Complex
Nature
Technology
22



Macroscope Standard Setting

Plug-and-play system architectures—supporting workflow design.

- Oct 17, 2015, ASTC Panel on "Plug-and-Play Macroscopes: Modular Hardware and Software Platforms that Render Data into Insights" in Montreal, Canada
- See other workshops and slides at http://cns.iu.edu/workshops

Data-code-vis-expertise marketplaces—easy access to relevant datasets and tools.

- OSGI+CIShell, D3, ESRI, Plotly, many others

Visualization hardware—support existing de-facto display standards, envision novel interfaces.

- Science on a Sphere, Beesley's Living Architectures, augmented realities, IoT

Science on a Sphere by NOAA

Beesley's Living Architectures

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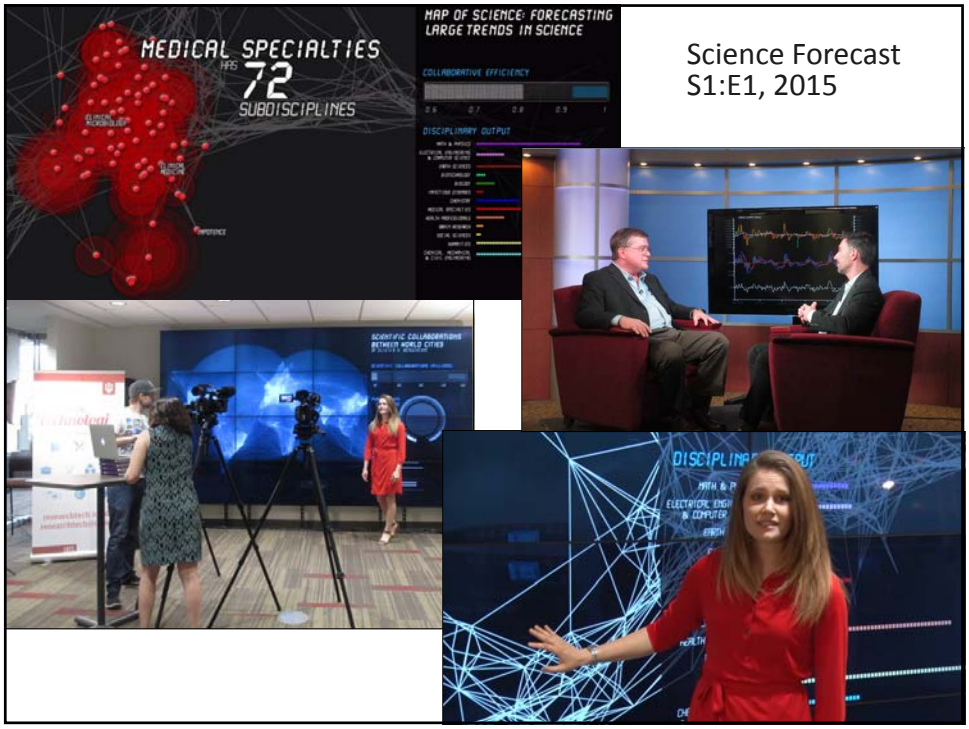
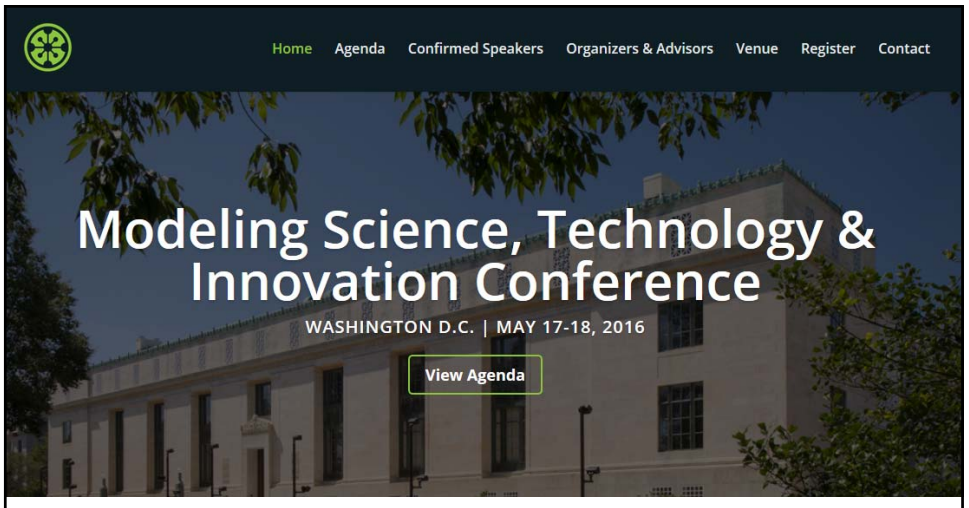


Science Forecast
S1:E1, 2015



This conference is co-funded by the NSF Science of Science and Innovation Policy (SciSIP) program. It brings together international experts and practitioners that develop and apply mathematical, statistical, and computational models to increase our understanding of the structure and dynamics of science, technology and innovation, see details at http://modsti.cns.iu.edu.

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Improving Data Visualization Literacy

Visualization Frameworks
IVMOOC
APPs

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How to Classify (Name & Make) Different Visualizations?

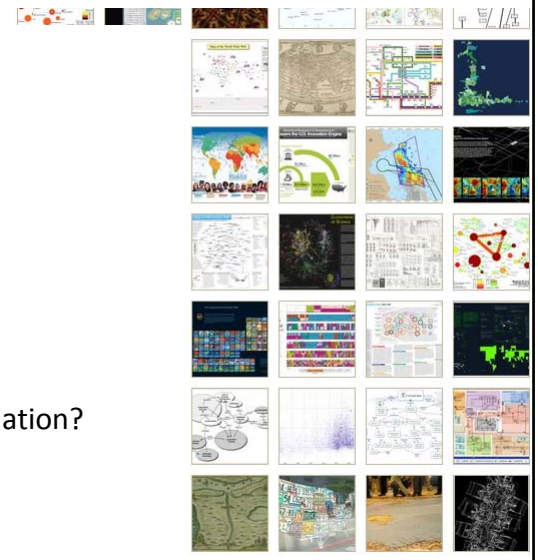
By

- User insight needs?
- User task types?

- Data to be visualized?
- Data transformation?

- Visualization technique?
- Visual mapping transformation?
- Interaction techniques?

- Or ?



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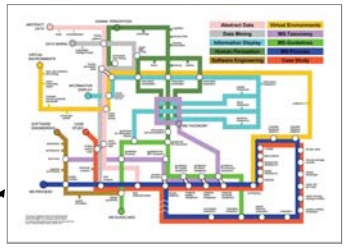
Different Question Types

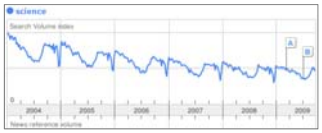
Terabytes of data

Descriptive & Predictive Models



Find your way

Find collaborators, friends



Identify trends

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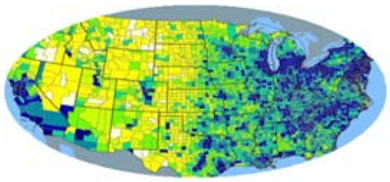
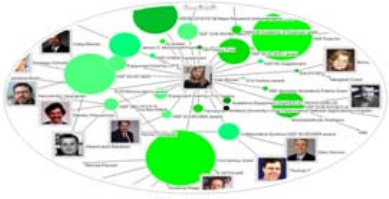
Different Levels of Abstraction/Analysis

Macro/Global
Population Level



Meso/Local
Group Level



Micro
Individual Level

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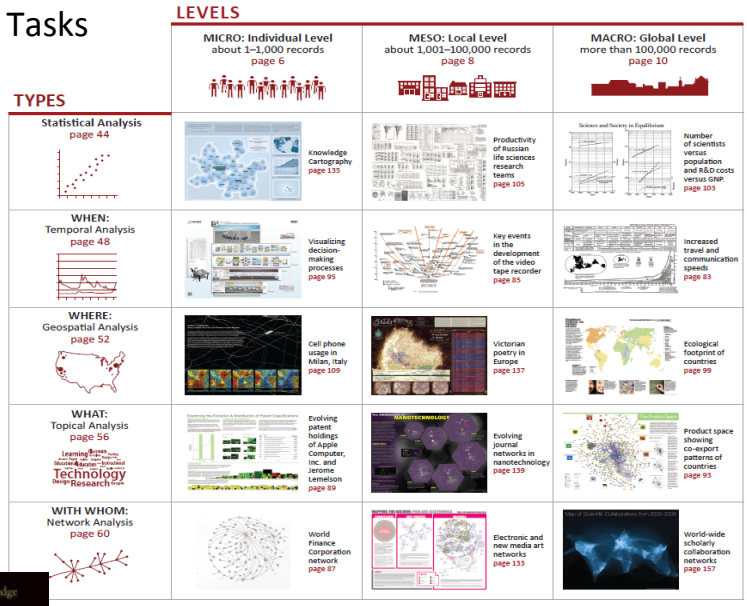
Tasks



See page 5

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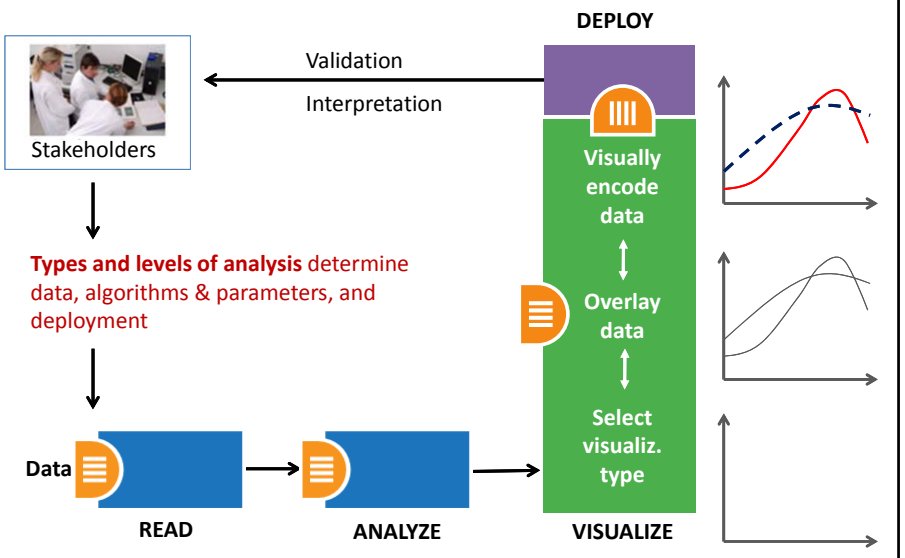
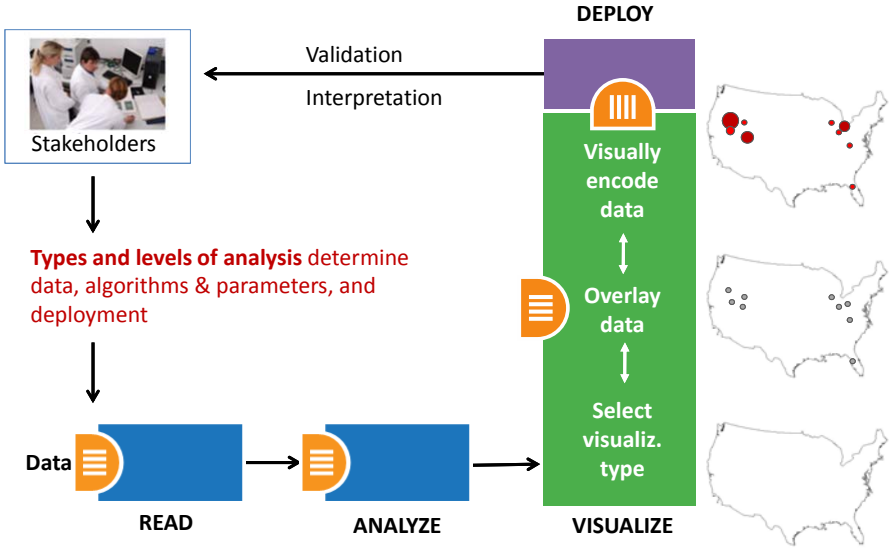
Needs-Driven Workflow Design



Needs-Driven Workflow Design



Visualization Framework

Insight Need Types page 26	Data Scale Types page 28	Visualization Types page 30	Graphic Symbol Types page 32	Graphic Variable Types page 34	Interaction Types page 26
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships	• nominal • ordinal • interval • ratio	• table • chart • graph • map • network layout	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion

See page 24

Visualization Framework

Basic Task Types								
Bertin, 1967	Wehrend & Lewis, 1996	Few, 2004	Yau, 2011	Rendgen & Wiedemann, 2012	Frankel, 2012	Tool: Many Eyes	Tool: Chart Chooser	Börner, 2014
selection	categorize			category				categorize/ cluster
order	rank	ranking					table	order/rank/ sort
	distribution	distribution					distribution	distributions (also outliers, gaps)
	compare	nominal comparison & deviation	differences		compare and contrast	compare data values	comparison	comparisons
		time series	patterns over time	time	process and time	track rises and falls over time	trend	trends (process and time)
		geospatial	spatial relations	location		generate maps		geospatial
quantity		part-to-whole	proportions		form and structure	see parts of whole, analyze text	composition	compositions (also of text)
association	correlate	correlation	relationships	hierarchy		relations between data points	relationship	correlations/ relationships

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Visualization Framework

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See page 24

Visualization Types (Reference Systems)

1. **Charts:** No reference system—e.g., Wordle.com, pie charts
2. **Tables:** Categorical axes that can be selected, reordered; cells can be color coded and might contain proportional symbols. Special kind of graph.
3. **Graphs:** Quantitative or qualitative (categorical) axes. Timelines, bar graphs, scatter plots.
4. **Geospatial maps:** Use latitude and longitude reference system. World or city maps.
5. **Network graphs:** Node position might depends on node attributes or node similarity. **Tree graphs:** hierarchies, taxonomies, genealogies. **Networks:** social networks, migration flows.

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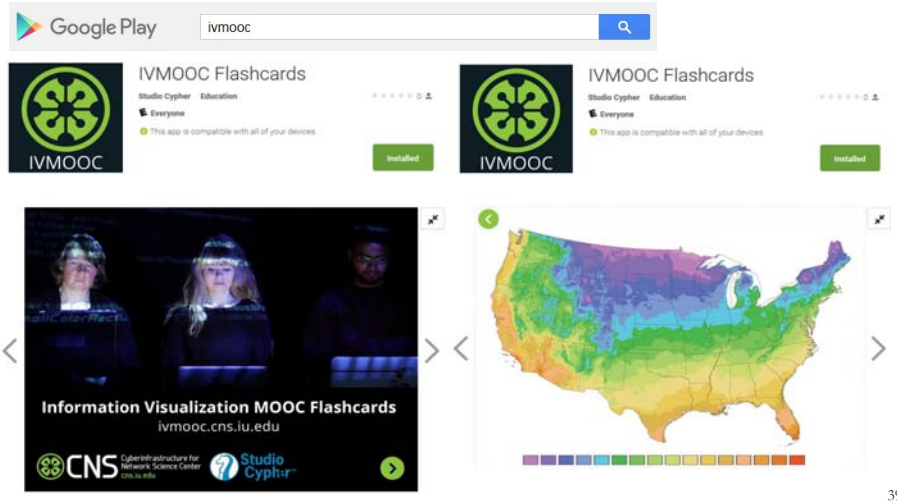
IVMOOC App – More than 60 visualizations

The "IVMOOC Flashcards" app can be downloaded from Google Play and Apple iOS stores.



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Visualization Framework

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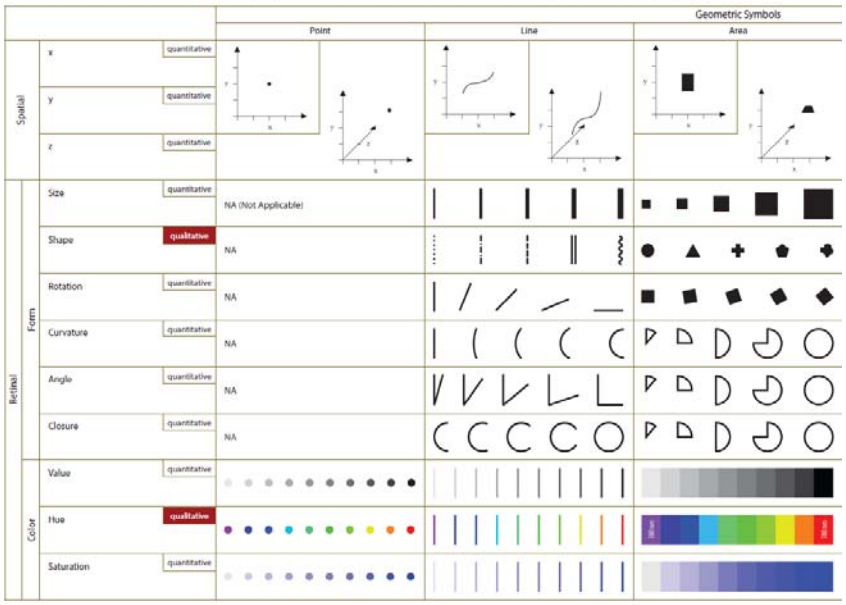
• categorize/cluster • order/rank/sort • distributions (also outliers, gaps) • comparisons • trends (process and time) • geospatial • compositions (also of text) • correlations/relationships	• nominal • ordinal • interval • ratio	• table • chart • graph • map • network layout	• geometric symbols point line area surface volume • linguistic symbols text numerals punctuation marks • pictorial symbols images icons statistical glyphs	• spatial position • retinal form color optics motion	• overview • zoom • search and locate • filter • details-on-demand • history • extract • link and brush • projection • distortion

See page 24

Graphic Variable Types Versus Graphic Symbol Types



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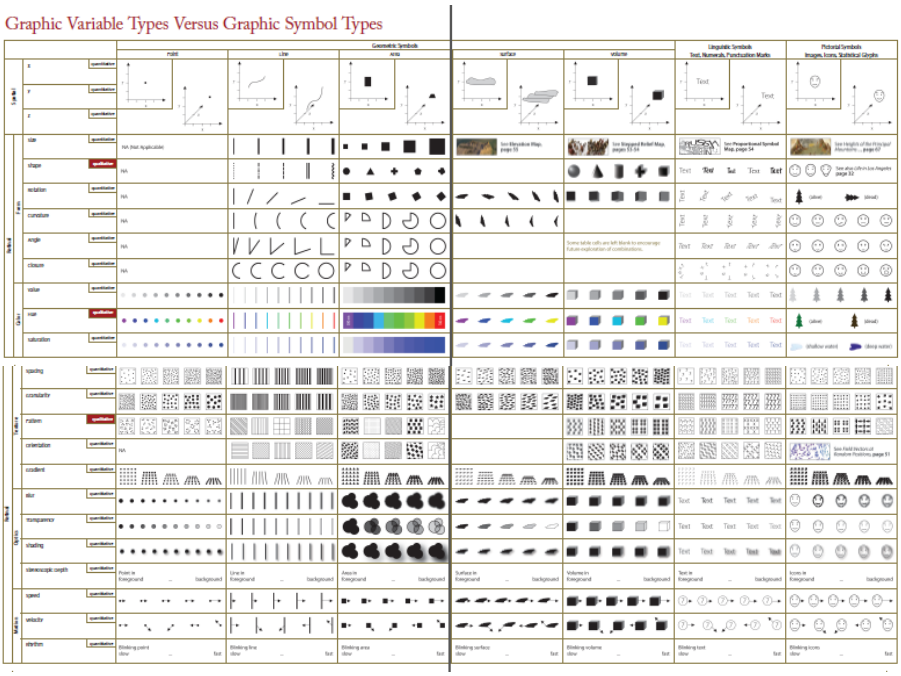
Graphic Variable Types Versus Graphic Symbol Types



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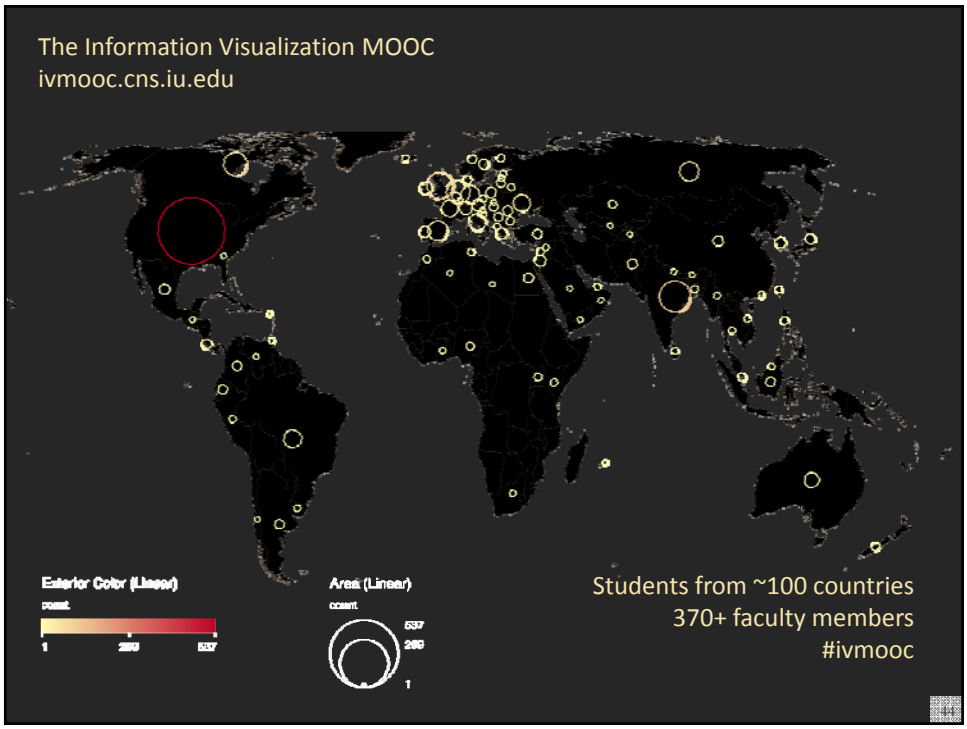
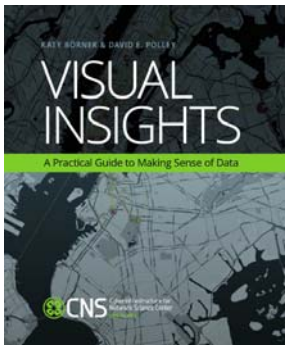
Register for free: http://ivmooc.cns.iu.edu. Class restarted Jan 12, 2016.

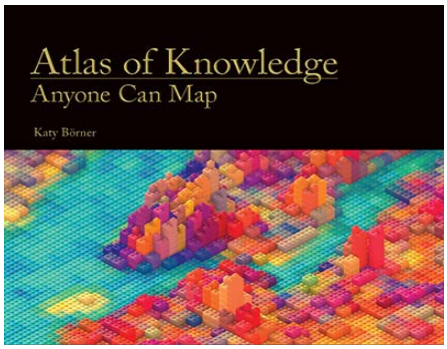


Books Used in the IVMOOC



Teaches timely knowledge:

Advanced algorithms, tools, and hands-on workflows.



Teaches timeless knowledge:

Visualization framework—exemplified using generic visualization examples and pioneering visualizations.

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Course Schedule

Part 1: Theory and Hands-On

- **Session 1** – Workflow Design and Visualization Framework
- **Session 2** – "When:" Temporal Data
- **Session 3** – "Where:" Geospatial Data
- **Session 4** – "What:" Topical Data

Mid-Term

- **Session 5** – "With Whom:" Trees
- **Session 6** – "With Whom:" Networks
- **Session 7** – Dynamic Visualizations and Deployment

Final Exam

Part 2: Students work in teams on client projects.

Final grade is based on Class Participation (10%), Midterm (30%), Final Exam (30%), and Client Project(30%).

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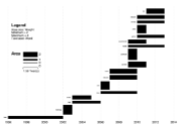
Load **One** File and Run **Many** Analyses and Visualizations

Times Cited	Publication Year	City of Publisher	Country	Journal Title (Full)	Title	Subject Category	Authors
12	2011	NEW YORK	USA	COMMUNICATIONS OF THE ACM	Plug-and-Play Macroscopes	Computer Science	Borner, K
18	2010	MALDEN	USA	CTS-CLINICAL AND TRANSLATIONAL SCIENCE	Advancing the Science of Team Science	Research & Experimental Medicine	Falk-Krzesinski, HJ|Borner, K|Contractor, N|Fiore, SM|Hall, KL|Keyton, J|Spring, B|Stokols, D|Trochim, W|Uzzi, B
13	2010	WASHINGTON	USA	SCIENCE TRANSLATIONAL MEDICINE	A Multi-Level Systems Perspective for the Science of Team Science	Cell Biology |Research & Experimental Medicine	Borner, K|Contractor, N|Falk-Krzesinski, HJ|Fiore, SM|Hall, KL|Keyton, J|Spring, B|Stokols, D|Trochim, W|Uzzi, B

Statistical Analysis–p. 44

Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2

Temporal Burst Analysis–p. 48



Geospatial Analysis–p. 52

Geospatial Analysis–p. 52

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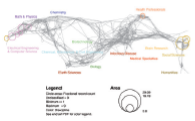
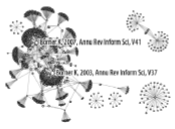
13	2010	WASHINGTON	USA	SCIENCE TRANSLATIONAL MEDICINE	A Multi-Level Systems Perspective for the Science of Team Science	Cell Biology |Research & Experimental Medicine	Borner, K|Contractor, N|Falk-Krzesinski, HJ|Fiore, SM|Hall, KL|Keyton, J|Spring, B|Stokols, D|Trochim, W|Uzzi, B

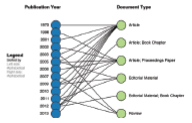
Topical Analysis–p. 56



Paper Citation Network–p. 60



Bi-Modal Network–p. 60



Co-author and many other bi-modal networks.

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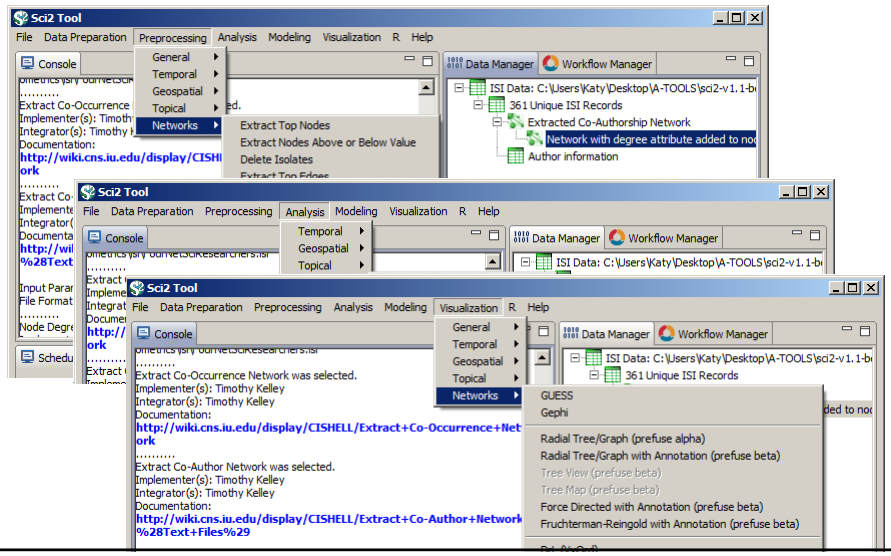
CNS Cyberinfrastructure for Network Science Center

Sci2 Tool Interface Components

Download tool for free at http://sci2.cns.iu.edu



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References

Börner, Katy, Chen, Chaomei, and Boyack, Kevin. (2003). **Visualizing Knowledge Domains.** In Blaise Cronin (Ed.), *ARIST*, Medford, NJ: Information Today, Volume 37, Chapter 5, pp. 179-255. http://ivl.slis.indiana.edu/km/pub/2003-borner-arist.pdf

Shiffrin, Richard M. and Börner, Katy (Eds.) (2004). **Mapping Knowledge Domains**. *Proceedings of the National Academy of Sciences of the United States of America*, 101(Suppl_1). http://www.pnas.org/content/vol101/suppl_1/

Börner, Katy (2010) **Atlas of Science: Visualizing What We Know**. The MIT Press. http://scimaps.org/atlas

Scharnhorst, Andrea, Börner, Katy, van den Besselaar, Peter (2012) **Models of Science Dynamics**. Springer Verlag.

Katy Börner, Michael Conlon, Jon Corson-Rikert, Cornell, Ying Ding (2012) **VIVO: A Semantic Approach to Scholarly Networking and Discovery**. Morgan & Claypool.

Katy Börner and David E Polley (2014) **Visual Insights: A Practical Guide to Making Sense of Data**. The MIT Press.

Börner, Katy (2015) **Atlas of Knowledge: Anyone Can Map**. The MIT Press. http://scimaps.org/atlas2

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All papers, maps, tools, talks, press are linked from http://cns.iu.edu
These slides will soon be at http://cns.iu.edu/docs/presentations

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