

## Data Visualization Literacy

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Indiana University Network Science Institute  
Indiana University, USA

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

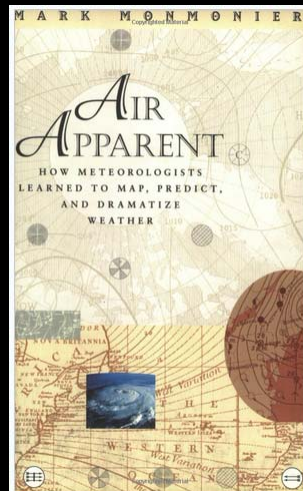
*IPAM, UCLA, Los Angeles, CA*

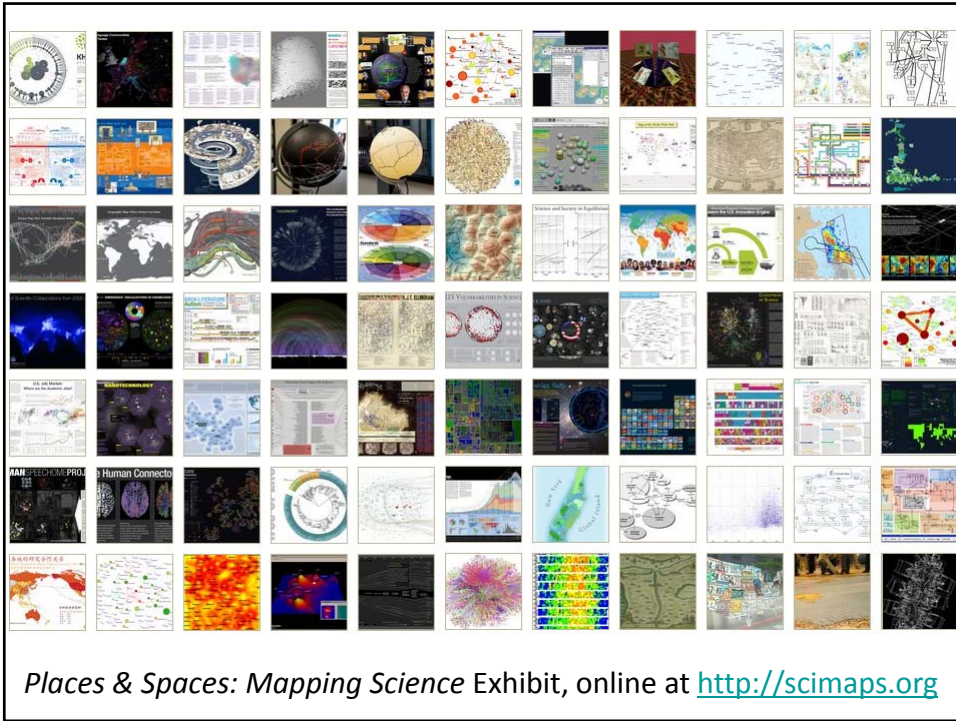
*April 11 - 15, 2016*



## Measuring, Mapping, and Communicating Our Collective Scholarly Knowledge

*Places & Spaces:  
Mapping Science  
Exhibit*





**INSTITUTE FOR THE FUTURE**  
**Science & Technology Outlook: 2005-2055**

Technology Horizons Program  
 Institute for the Future  
 134 University Avenue, 2nd Floor, Palo Alto, CA 94301  
 1-800-854-6321 • 650-854-1900 • [www.iftf.org](http://www.iftf.org)

A map is a tool for mapping an unknown terrain in the case of war. Science is technology. In 2005-2055, the terrain we're mapping is the path our world will take over the next 50 years. However, the map of the future is not a map for prediction; it's a map for the pursuit of possibilities. Not to compare to modern navigation techniques which use only a single number of sailing legs, the IFTF contributes to what the map looks like. It does not provide a single path, but rather a series of paths that branch out from a central point. These paths represent different scenarios for the future, based on different assumptions about the role of science and technology. The map is not a prediction; it's a tool for exploration. It shows the possibilities that science and technology can create, and the challenges that we will face. It's a map of the future, and it's ours to explore.

**MAP TRENDS**

**Health Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on health care is likely to be significant. The impact of population growth on health care is likely to be significant. The impact of population growth on health care is likely to be significant.

**Energy Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on energy is likely to be significant. The impact of population growth on energy is likely to be significant. The impact of population growth on energy is likely to be significant.

**Space Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on space is likely to be significant. The impact of population growth on space is likely to be significant. The impact of population growth on space is likely to be significant.

**Information Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on information is likely to be significant. The impact of population growth on information is likely to be significant. The impact of population growth on information is likely to be significant.

**Environment Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on the environment is likely to be significant. The impact of population growth on the environment is likely to be significant. The impact of population growth on the environment is likely to be significant.

**Society Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on society is likely to be significant. The impact of population growth on society is likely to be significant. The impact of population growth on society is likely to be significant.

**WFO TRENDS**

**Workforce Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on the workforce is likely to be significant. The impact of population growth on the workforce is likely to be significant. The impact of population growth on the workforce is likely to be significant.

**Education Trends**  
 In the next 50 years, the impact of population growth as a source of innovation and discovery in scientific research is likely to be significant. The impact of population growth on education is likely to be significant. The impact of population growth on education is likely to be significant. The impact of population growth on education is likely to be significant.

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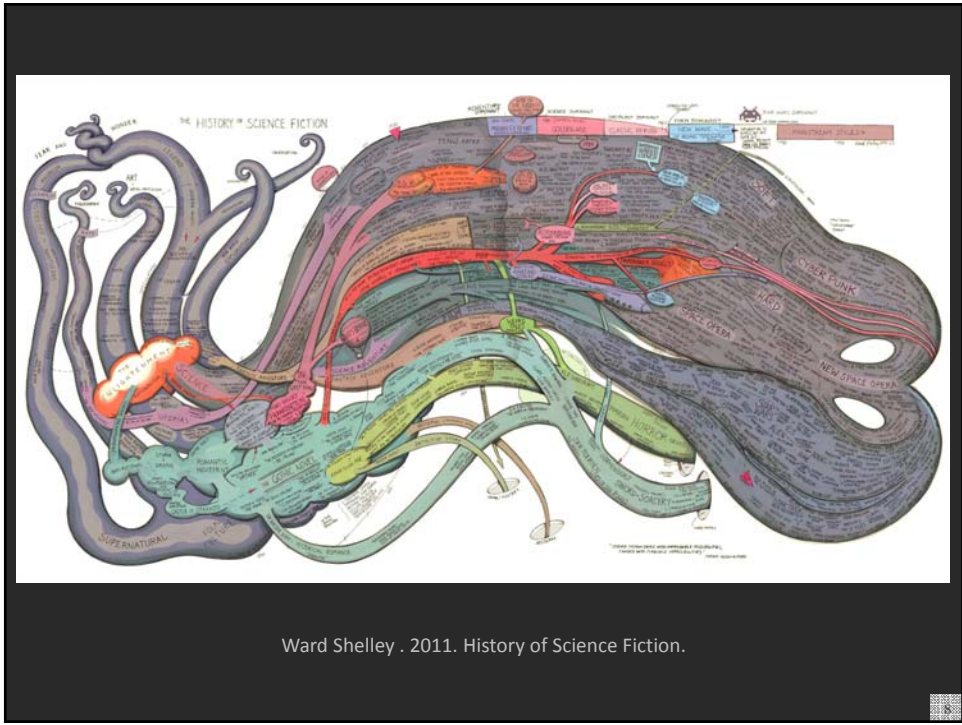
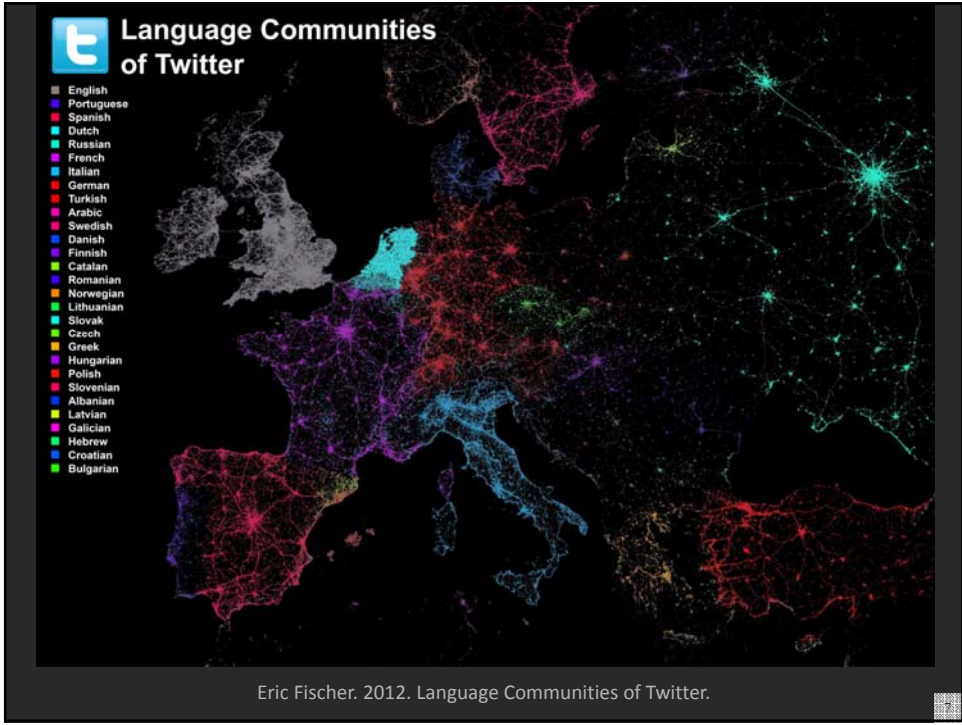
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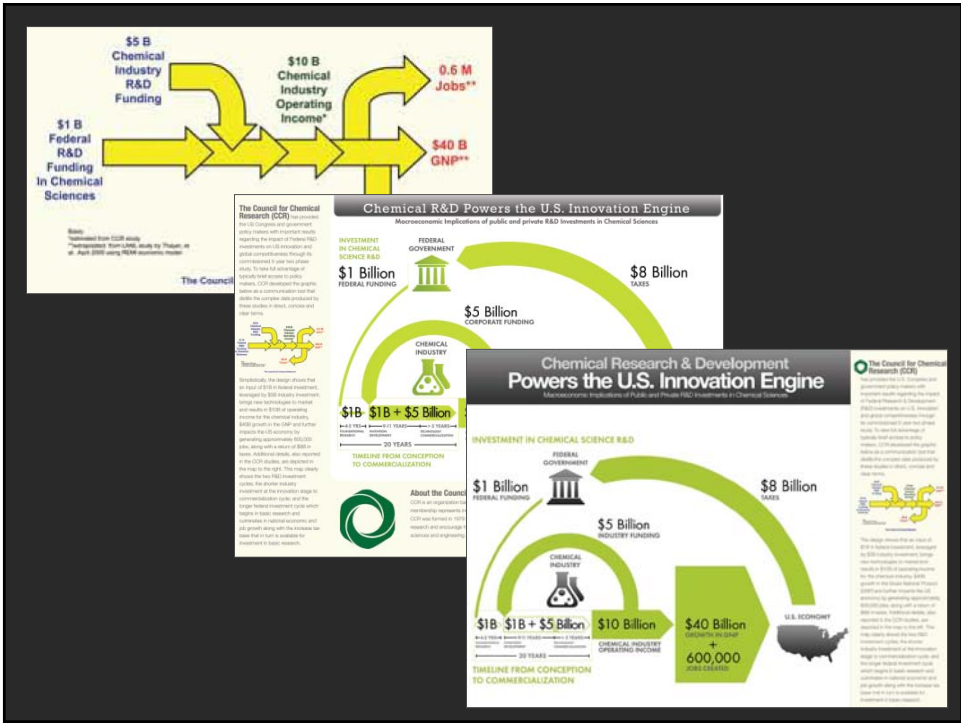
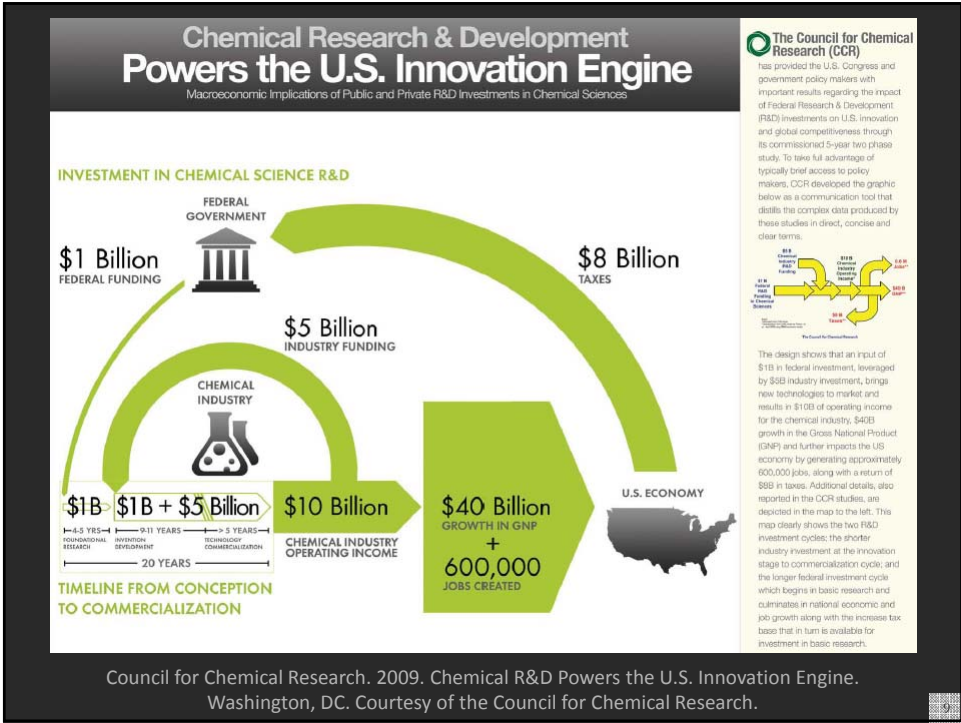
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Alex Soojung-Kim Pang, David Pescovitz, Marina Gorbis, Jean Hagan . 2006. *Science & Technology Outlook: 2005-2055*.






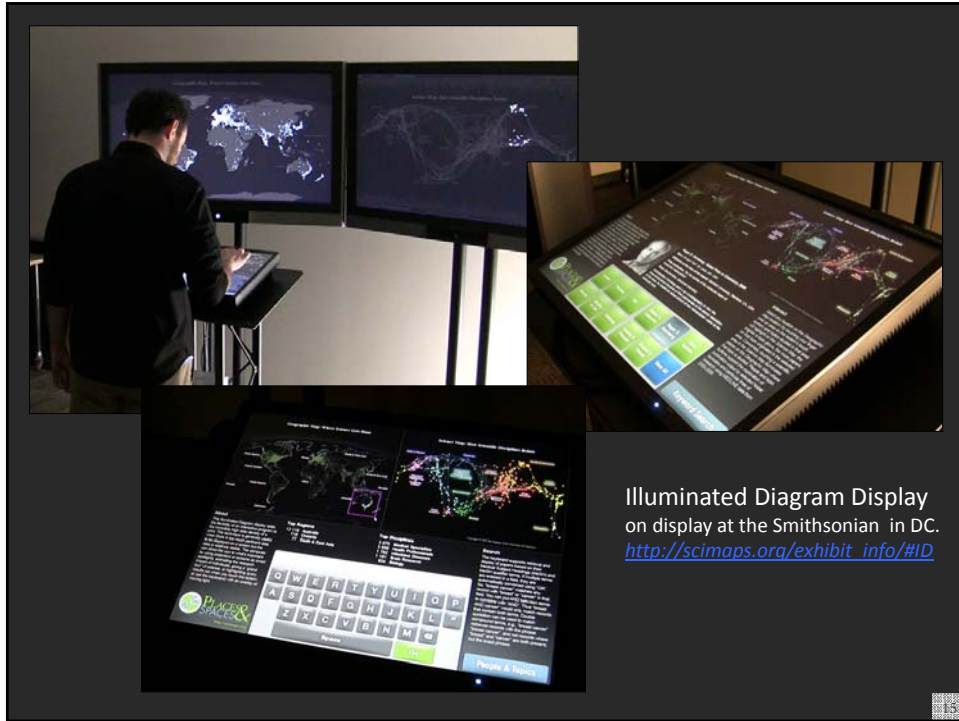






 **Kristi Holmes** @kristiholmes · Apr 30  
Excited for @cnscenter Places&Spaces at @gallerlibrary! @katycns  
@NUCATsinstitute #unpackingcrates #viz

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



### Geographic Map: Where Science Gets Done

North America, Europe, North & East Asia, South & East Asia, Oceania, Africa, South America, Australia, Americas

### Science Map: How Scientific Disciplines Relate

Math & Physics, Chemistry, Health Professions, Social Sciences, Medical Sciences, Biotechnology, Biomedical & Chemical Engineering, Earth Sciences, Biology, Humanities, Electrical Engineering & Computer Science, Aerospace, Chemical, Mechanical & Civil Engineering, Medicine, Diseases

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**About**

This illuminated diagram display adds the flexibility of an interactive program to the incredibly high data density of a print. This technique is generally useful when there is too much pertinent data to be displayed on a screen but the data is relatively stable. The computer can direct the eye to what's important by using projectors or screens as smart spotlights, animating the research impact of individuals, giving a "grand tour" of science, or highlighting query results (as when you touch the lectern or use the keyboard) with an overlay of moving light.

<http://scimaps.org>

**Top Five Continents**

- North America - 4,000 records
- South & East Asia - 3,589
- Australia - 2,421
- Africa - 2,208
- South America - 1,562

**Top Five Scientific Disciplines**

- Math & Physics - 4,000 records
- Health Professions - 3,589
- Social Sciences - 2,431
- Aerospace, Chemical, Mechanical & Civil Engineering - 2,208
- Humanities - 1,562

Input your search query here

**Go**

**Search**

The keyboard supports retrieval and display of papers based on their Medical Subject Headings (MeSH) and MeSH qualifier terms. If multiple terms are entered in a field, they are automatically combined using "OR". So, "breast cancer" matches any record with "breast" or "cancer" in that field. You can put AND between terms to combine with "AND". Thus "breast AND cancer" would only match records that contain both terms. Double quotation can be used to match compound terms, e.g., "breast cancer" retrieves records with the phrase "breast cancer", and not records where "breast" and "cancer" are both present, but the exact phrase.

**People & Topics**



### Geographic Map: Where Science Gets Done

### Science Map: How Scientific Disciplines Relate

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#### About

This Illuminated Diagram display adds the flexibility of an interactive program to the incredibly high data density of a print. This technique is generally useful when there is too much pertinent data to be displayed on a screen but the data is relatively stable. The computer can direct the eye to what's important by using projectors or screens as smart spotlights, animating the research impact of individuals, giving a "grand tour" of science, or highlighting query results (as when you touch the lectern or use the keyboard) with an overlay of moving light.

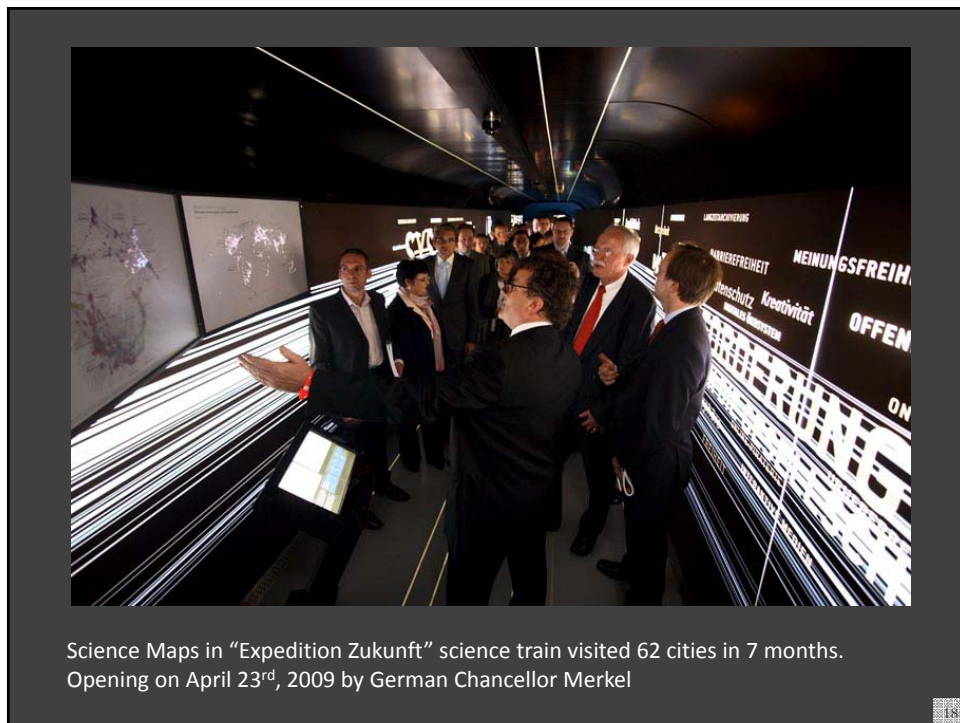
#### Elinor Ostrom - Nobel Prize in Economic Sciences 2009

**Born:** 7 August 1933, New York, NY, USA  
**Affiliation at the time of the award:** Indiana University, Bloomington, IN, USA, Arizona State University, Tempe, AZ, USA  
**Prize motivation:** "for her analysis of economic governance, especially the commons"  
**Field:** Economic governance  
**Contribution:** Challenged the conventional wisdom by demonstrating how local property can be successfully managed by local commons without any control by central authorities or privatization.

Cancer	Cloning	HIV	Robert G. Edwards	Roger D. Kornberg	Elinor Ostrom
Obesity	Quality of Life	Smoking	Stanley B. Prusiner	Ahmed H. Zewail	View All

#### Interact

Select any location on the Geographic Map location (by brushing your finger over an area on the lectern's touch screen) and topics studied in that area will highlight on the Science Map: the brighter a topic glows, the more papers on that topic originated in the selected area. Conversely, touching a scientific area in the Science Map illuminates places on the Geographic Map where that topic is studied. People and topic buttons support the exploration of publication output by selected Noble laureates and particular lines of research using MEDLINE data from 2000-2009.





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

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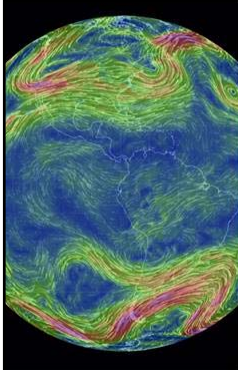
**Seeing for  
Action - Using  
Maps and  
Graphs  
to Protect the  
Public's Health.**

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


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① **MACROSCOPES FOR INTERACTING WITH SCIENCE**







Earth



AcademyScope



Mapping Global Society




Charting Culture


<http://scimaps.org/iteration/11>

**Microscopes, Telescopes, Macrosopes Plug-and-Play Macrosopes**


The Infinitely Great



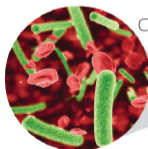
Telescope



Stars




Microscope




Cells

The Infinitely Small




Macroscope

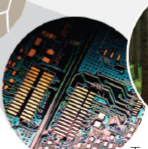
The Infinitely Complex




Galaxies



Society



Technology



Nature

22

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Hidalgo, César A., Bailey Klings, Albert-László Barabási, and Ricardo Hausmann, 2007. See also The Product Space map from Phase I of Places & Spaces.

## Call for Macroscope Tools for the *Places & Spaces: Mapping Science* Exhibit (2016) <http://scimaps.org/call>

**Background and Goals**

The *Places & Spaces: Mapping Science* exhibit was created to in communicate human activity and scientific progress on a globe that enable the close inspection of large-scale maps in public conferences; (2) novel, interactive macroscope tools that let!

Themes for the upcoming iterations/years are:

- 11th Iteration (2015): Macroscopes for Interacting With Science
- 12th Iteration (2016): Macroscopes for Making Sense of Science
- 13th Iteration (2017): Macroscopes for Forecasting Science
- 14th Iteration (2018): Macroscopes for Economic Decision Makers
- 15th Iteration (2019): Macroscopes for Science Policy Makers

2.3

## 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+ClShell, 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

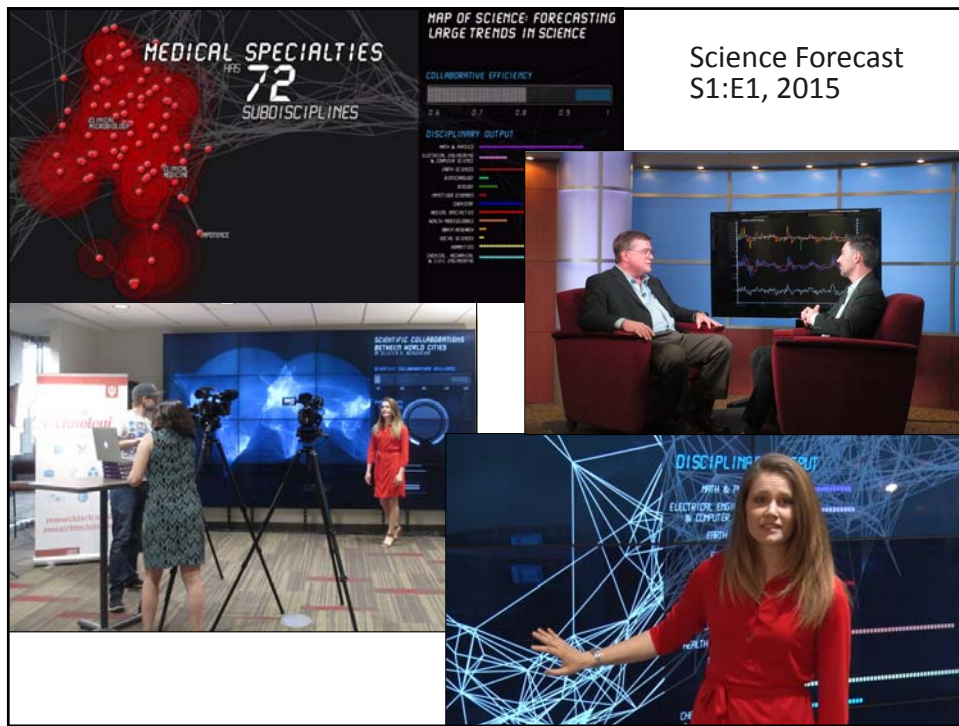


Science on a Sphere by NOAA




Beesley’s Living Architectures

2.4



Science Forecast  
S1:E1, 2015


[Home](#) [Agenda](#) [Confirmed Speakers](#) [Organizers & Advisors](#) [Venue](#) [Register](#) [Contact](#)

# Modeling Science, Technology & Innovation Conference

WASHINGTON D.C. | MAY 17-18, 2016

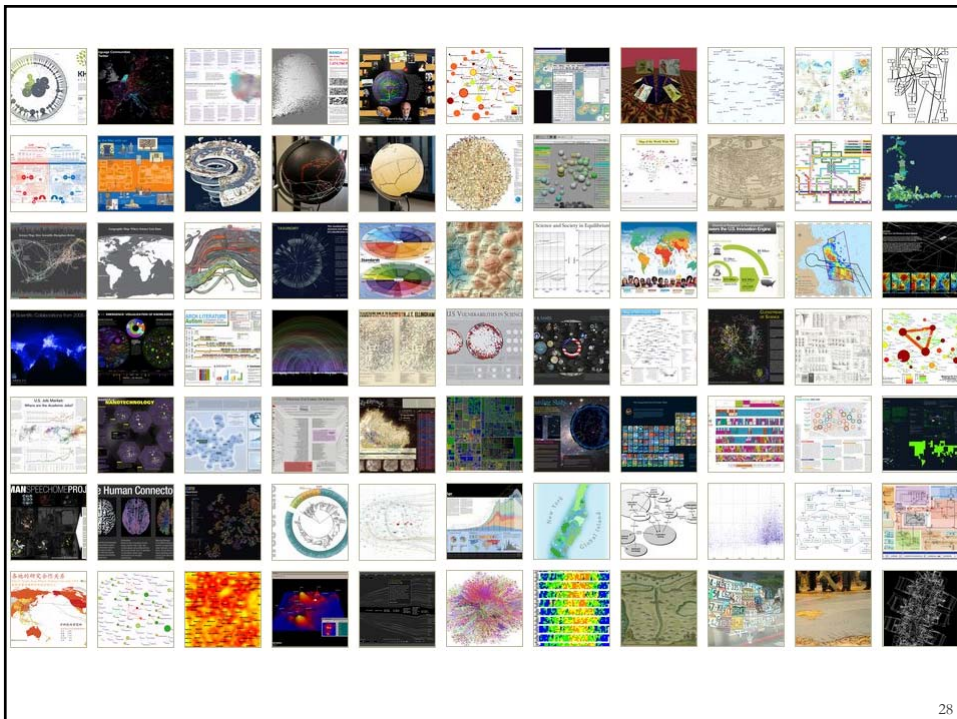
[View Agenda](#)

*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

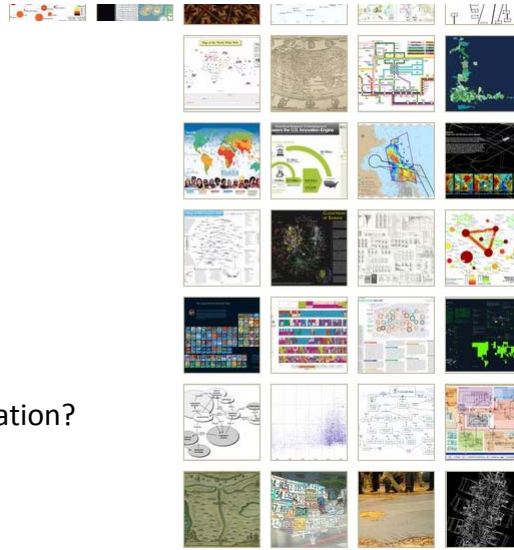
*Visualization Frameworks*  
*IVMOOC*  
*APPs*



## 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

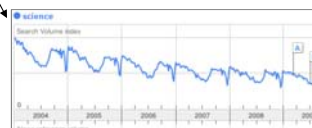
Descriptive & Predictive Models



Find your way



Find collaborators, friends

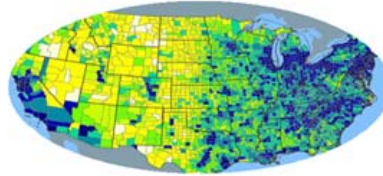


Identify trends

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# Different Levels of Abstraction/Analysis

Macro/Global  
Population Level



Meso/Local  
Group Level



Micro  
Individual Level



## Tasks

### LEVELS

### TYPES

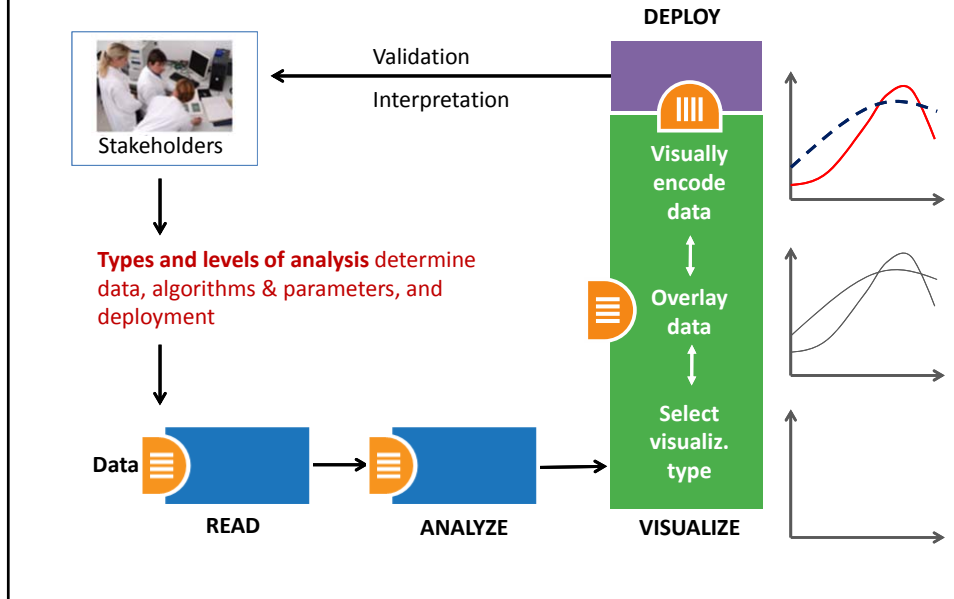
	MICRO: Individual Level about 1-1,000 records page 6	MESO: Local Level about 1,001-100,000 records page 8	MACRO: Global Level more than 100,000 records page 10
<b>Statistical Analysis</b> page 44			
<b>WHEN: Temporal Analysis</b> page 48			
<b>WHERE: Geospatial Analysis</b> page 52			
<b>WHAT: Topical Analysis</b> page 56			
<b>WITH WHOM: Network Analysis</b> page 60			



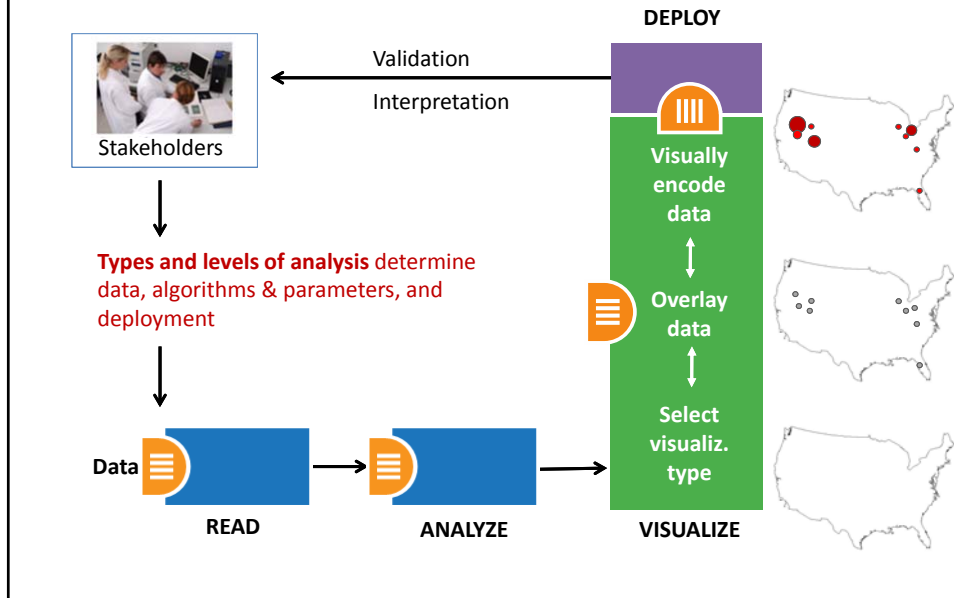
See page 5



## Needs-Driven Workflow Design

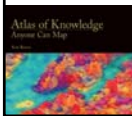


## Needs-Driven Workflow Design



# 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
<ul style="list-style-type: none"> <li>categorize/cluster</li> <li>order/rank/sort</li> <li>distributions (also outliers, gaps)</li> <li>comparisons</li> <li>trends (process and time)</li> <li>geospatial</li> <li>compositions (also of text)</li> <li>correlations/relationships</li> </ul>	<ul style="list-style-type: none"> <li>nominal</li> <li>ordinal</li> <li>interval</li> <li>ratio</li> </ul>	<ul style="list-style-type: none"> <li>table</li> <li>chart</li> <li>graph</li> <li>map</li> <li>network layout</li> </ul>	<ul style="list-style-type: none"> <li>geometric symbols                             <ul style="list-style-type: none"> <li>point</li> <li>line</li> <li>area</li> <li>surface</li> <li>volume</li> </ul> </li> <li>linguistic symbols                             <ul style="list-style-type: none"> <li>text</li> <li>numerals</li> <li>punctuation marks</li> </ul> </li> <li>pictorial symbols                             <ul style="list-style-type: none"> <li>images</li> <li>icons</li> <li>statistical glyphs</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>spatial                             <ul style="list-style-type: none"> <li>position</li> </ul> </li> <li>retinal                             <ul style="list-style-type: none"> <li>form</li> <li>color</li> <li>optics</li> <li>motion</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>overview</li> <li>zoom</li> <li>search and locate</li> <li>filter</li> <li>details-on-demand</li> <li>history</li> <li>extract</li> <li>link and brush</li> <li>projection</li> <li>distortion</li> </ul>



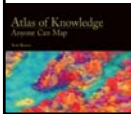
See page 24

# 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

## 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
<ul style="list-style-type: none"> <li>• categorize/cluster</li> <li>• order/rank/sort</li> <li>• distributions (also outliers, gaps)</li> <li>• comparisons</li> <li>• trends (process and time)</li> <li>• geospatial</li> <li>• compositions (also of text)</li> <li>• correlations/relationships</li> </ul>	<ul style="list-style-type: none"> <li>• nominal</li> <li>• ordinal</li> <li>• interval</li> <li>• ratio</li> </ul>	<ul style="list-style-type: none"> <li>• table</li> <li>• chart</li> <li>• graph</li> <li>• map</li> <li>• network layout</li> </ul>	<ul style="list-style-type: none"> <li>• geometric symbols                             <ul style="list-style-type: none"> <li>point</li> <li>line</li> <li>area</li> <li>surface</li> <li>volume</li> </ul> </li> <li>• linguistic symbols                             <ul style="list-style-type: none"> <li>text</li> <li>numerals</li> <li>punctuation marks</li> </ul> </li> <li>• pictorial symbols                             <ul style="list-style-type: none"> <li>images</li> <li>icons</li> <li>statistical glyphs</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• spatial                             <ul style="list-style-type: none"> <li>position</li> </ul> </li> <li>• retinal                             <ul style="list-style-type: none"> <li>form</li> <li>color</li> <li>optics</li> <li>motion</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• overview</li> <li>• zoom</li> <li>• search and locate</li> <li>• filter</li> <li>• details-on-demand</li> <li>• history</li> <li>• extract</li> <li>• link and brush</li> <li>• projection</li> <li>• distortion</li> </ul>



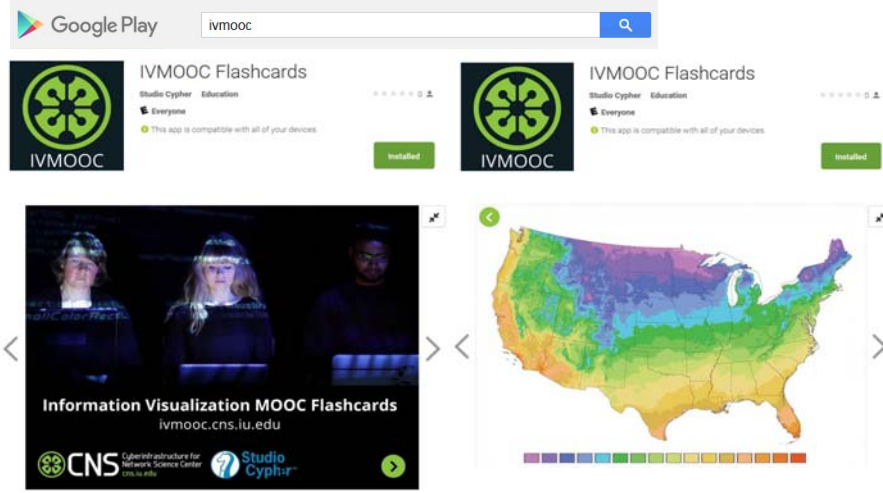
See page 24

## 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.

## IVMOOC App – More than 60 visualizations

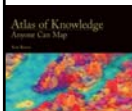
The “IVMOOC Flashcards” app can be downloaded from Google Play and Apple iOS stores.



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## Visualization Framework

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
<ul style="list-style-type: none"> <li>• categorize/cluster</li> <li>• order/rank/sort</li> <li>• distributions (also outliers, gaps)</li> <li>• comparisons</li> <li>• trends (process and time)</li> <li>• geospatial</li> <li>• compositions (also of text)</li> <li>• correlations/relationships</li> </ul>	<ul style="list-style-type: none"> <li>• nominal</li> <li>• ordinal</li> <li>• interval</li> <li>• ratio</li> </ul>	<ul style="list-style-type: none"> <li>• table</li> <li>• chart</li> <li>• graph</li> <li>• map</li> <li>• network layout</li> </ul>	<ul style="list-style-type: none"> <li>• geometric symbols                             <ul style="list-style-type: none"> <li>point</li> <li>line</li> <li>area</li> <li>surface</li> <li>volume</li> </ul> </li> <li>• linguistic symbols                             <ul style="list-style-type: none"> <li>text</li> <li>numerals</li> <li>punctuation marks</li> </ul> </li> <li>• pictorial symbols                             <ul style="list-style-type: none"> <li>images</li> <li>icons</li> <li>statistical glyphs</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• spatial                             <ul style="list-style-type: none"> <li>position</li> </ul> </li> <li>• retinal                             <ul style="list-style-type: none"> <li>form</li> <li>color</li> <li>optics</li> <li>motion</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• overview</li> <li>• zoom</li> <li>• search and locate</li> <li>• filter</li> <li>• details-on-demand</li> <li>• history</li> <li>• extract</li> <li>• link and brush</li> <li>• projection</li> <li>• distortion</li> </ul>



See page 24

## Graphic Variable Types Versus Graphic Symbol Types


		Geometric Symbols			
		Point	Line	Area	
Spatial	x	quantitative			
	y	quantitative			
	z	quantitative			
Form	Size	quantitative	NA (Not Applicable)		
	Shape	qualitative	NA		
	Rotation	quantitative	NA		
	Curvature	quantitative	NA		
	Angle	quantitative	NA		
	Closure	quantitative	NA		
	Value	quantitative			
Color	Hue	qualitative			
	Saturation	quantitative			


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## Graphic Variable Types Versus Graphic Symbol Types

		Geometric Symbols			Linguistic Symbols			Pictorial Symbols		
		Point	Line	Area	Color	Value	Text, Markers, Punctuation Marks	Images, Icons, Symbolic Objects		
Spatial	x	quantitative								
	y	quantitative								
	z	quantitative								
Form	Size	quantitative	NA (Not Applicable)							
	Shape	qualitative	NA							
	Rotation	quantitative	NA							
	Curvature	quantitative	NA							
	Angle	quantitative	NA							
	Closure	quantitative	NA							
	Value	quantitative								
Color	Hue	qualitative								
	Saturation	quantitative								
Material	spacing	quantitative								
	consistency	quantitative								
	pattern	qualitative								
	orientation	quantitative								
	contrast	quantitative								
	blur	quantitative								
	transparency	quantitative								
	shading	quantitative								
	strokecap length	quantitative								
	opacity	quantitative								
visibility	quantitative									
depth	quantitative									

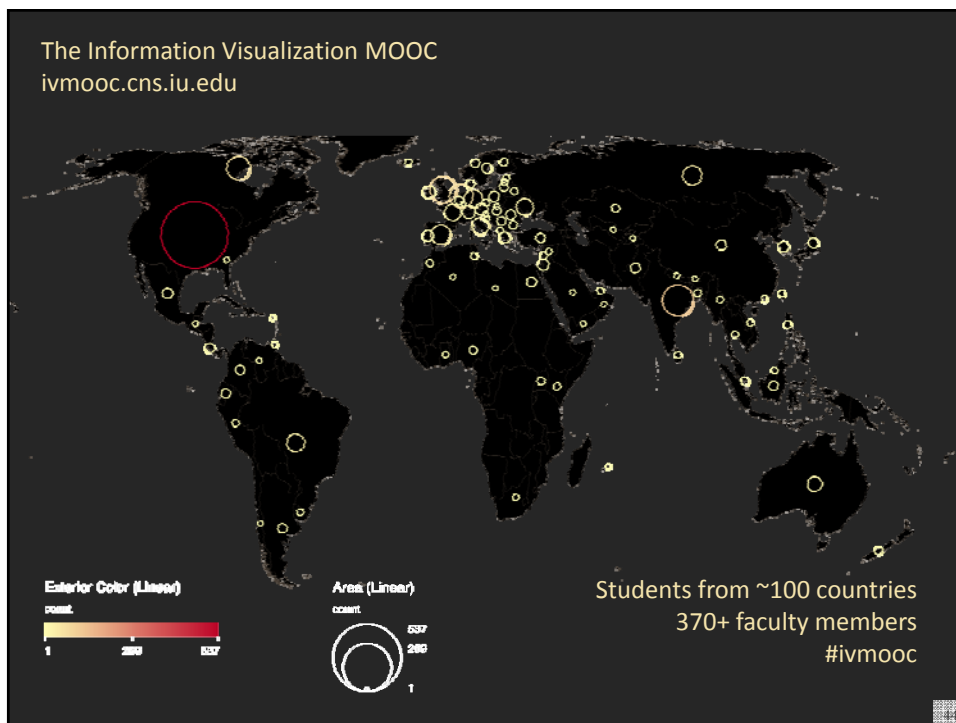
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 IVMOOC 2016 MENU

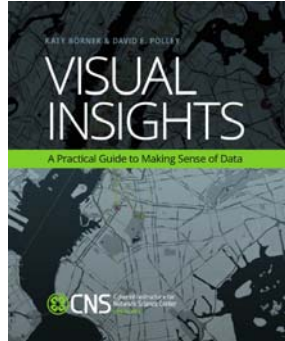


Information Visualization MOOC ivmooc.cns.iu.edu

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

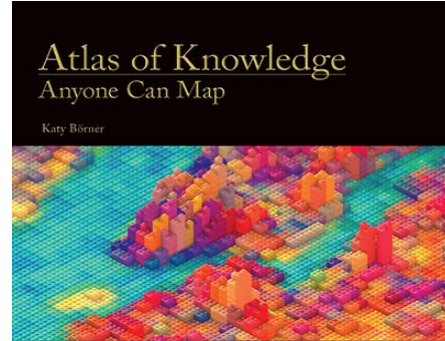


## Books Used in the IVMOOC



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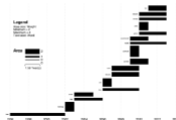
## Load **One** File and Run **Many** Analyses and Visualizations

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 Microscopes	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

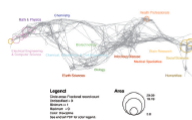


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## Load **One** File and Run **Many** Analyses and Visualizations

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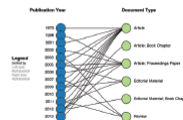
Topical Analysis—p. 56



Paper Citation Network—p. 60



Bi-Modal Network—p. 60



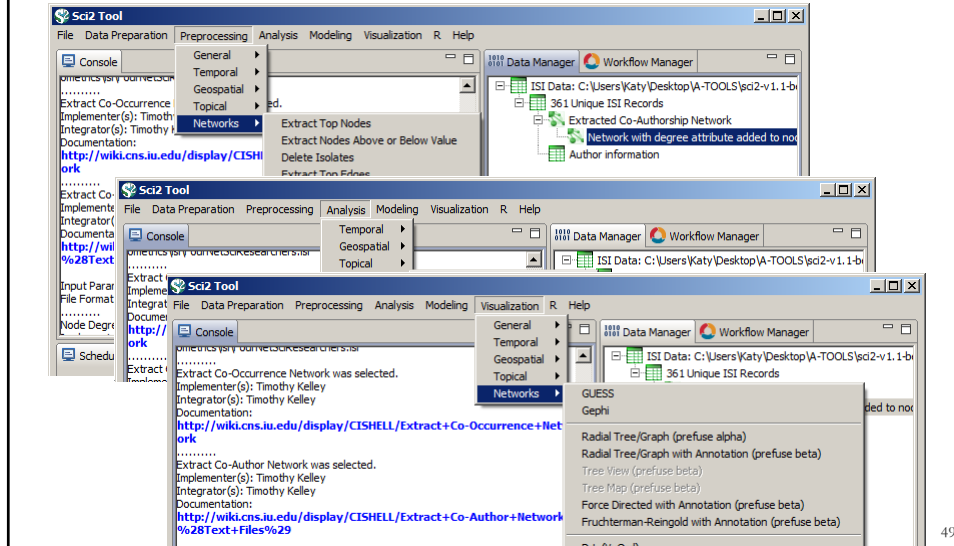
Co-author and many other bi-modal networks.

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## Sci2 Tool Interface Components

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



## 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/](http://www.pnas.org/content/vol101/suppl_1/)

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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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 These slides will soon be at <http://cns.iu.edu/docs/presentations>  
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