



## Data Visualization Literacy

- Andee: What does education want from data visualization?
- Joe: What do data visualizations need to be comprehensible?
- Katy: What frameworks can we provide for understanding data visualizations?
- Peggy: How do we make data visualization accessible on the museum floor?
- Bryan: How do we make data visualization accessible on the museum floor?

*ASTC Conference  
Tampa, Florida*

*September 25, 2016*

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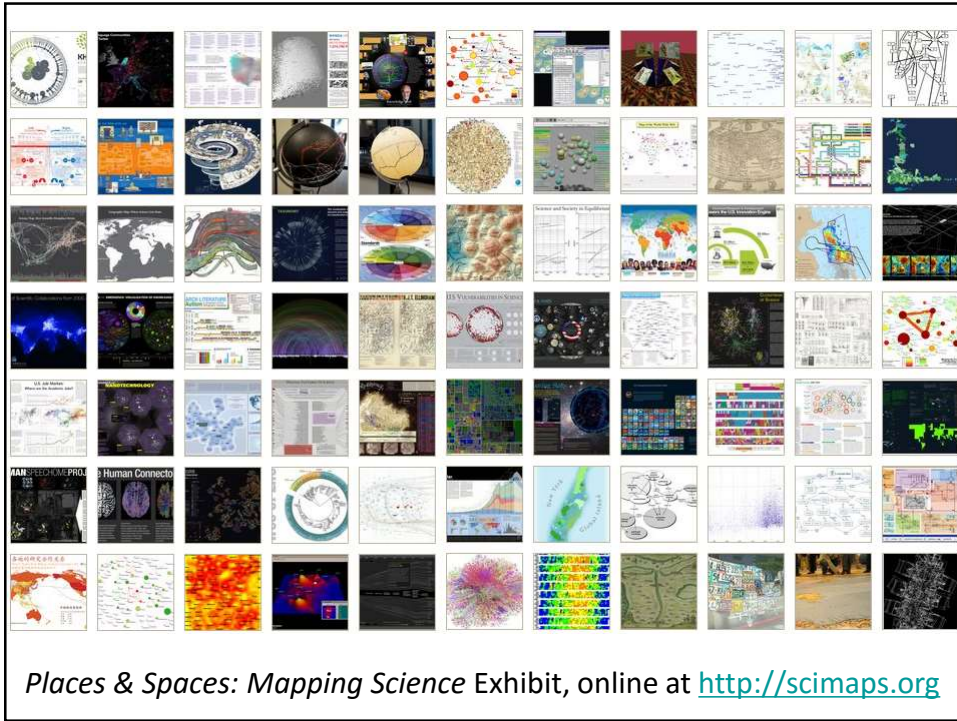
## Data Visualization Literacy: Visualization Frameworks

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*ASTC Conference  
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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 ?

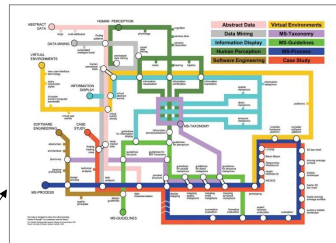


## Different Question Types



Terabytes of data

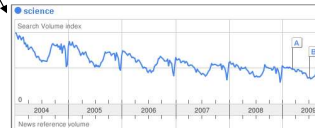
Descriptive &  
Predictive  
Models



Find your way



Find collaborators, friends

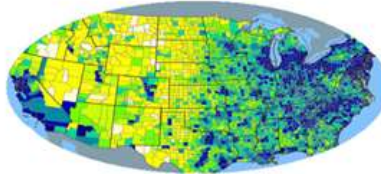


Identify trends

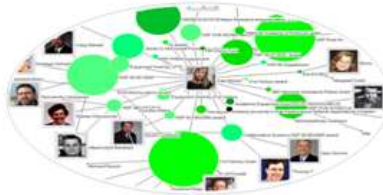
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## Different Levels of Abstraction/Analysis

Macro/Global  
Population Level



Meso/Local  
Group Level



Micro  
Individual Level



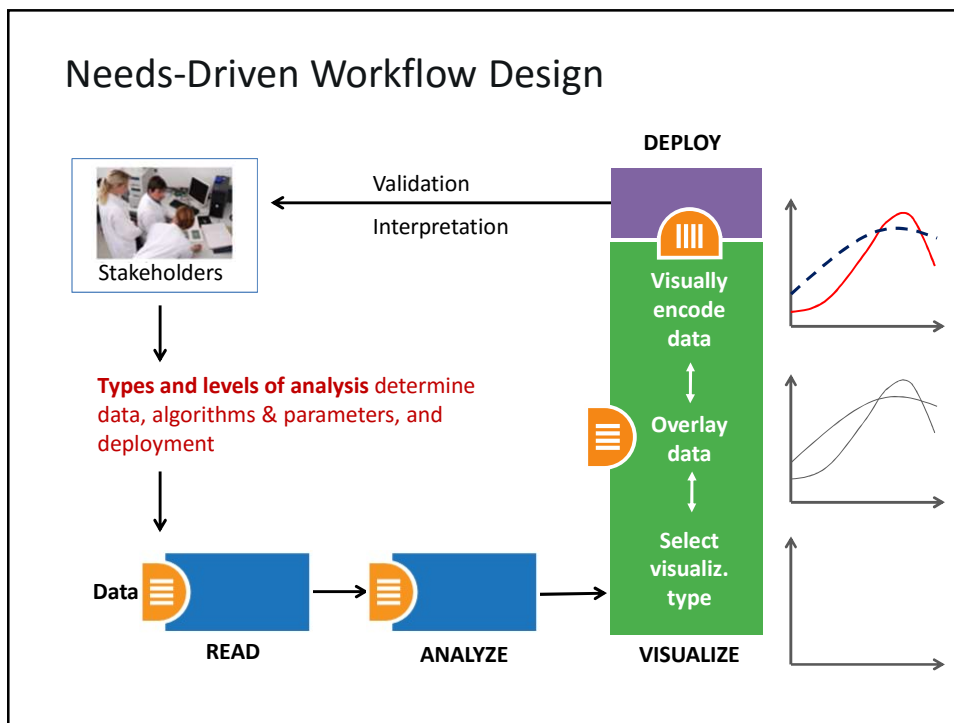
6

Tasks	LEVELS			
	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	
TYPES	Statistical Analysis page 44 	Knowledge Cartography page 135 	Productivity Russian life sciences research teams page 305 	Science and Society in Equilibrium Number of scientists versus population and R&D costs versus GNP page 303 
WHEN: Temporal Analysis page 48 	Visualizing decision-making processes page 95 	Key events in the development of the video tape recorder page 85 	Increased travel and communication speeds page 83 	
WHERE: Geospatial Analysis page 52 	Cell phone usage in Milan, Italy page 199 	Victorian poetry in Europe page 137 	Ecological footprint of countries page 99 	
WHAT: Topical Analysis page 56 	Evolving patent holdings of Apple Computer, Inc. and patents Lemelson page 89 	Evolving journal networks in nanotechnology page 139 	Product space showing co-export patterns of countries page 93 	
WITH WHOM: Network Analysis page 60 	World Finance Corporation network page 87 	Electronic and new media art networks page 133 	World-wide scholarly collaboration networks page 137 	

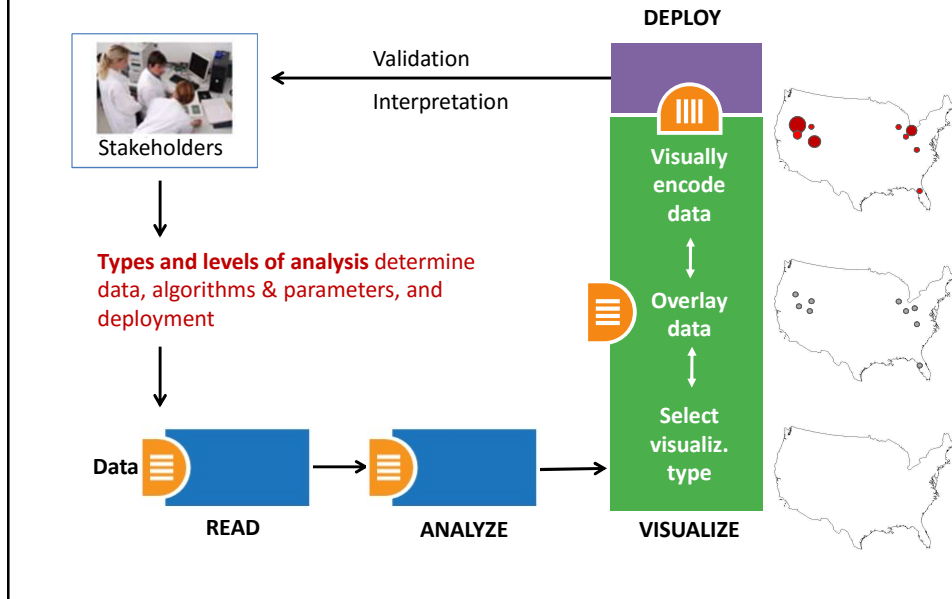
Atlas of Knowledge  
Know-Can-Map  
© 2010

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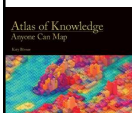


## Needs-Driven Workflow Design



## 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> <li>• retinal                                     <ul style="list-style-type: none"> <li>• form</li> <li>• color</li> <li>• optics</li> <li>• motion</li> </ul> </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>



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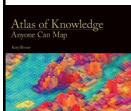
## Visualization Framework

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

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>



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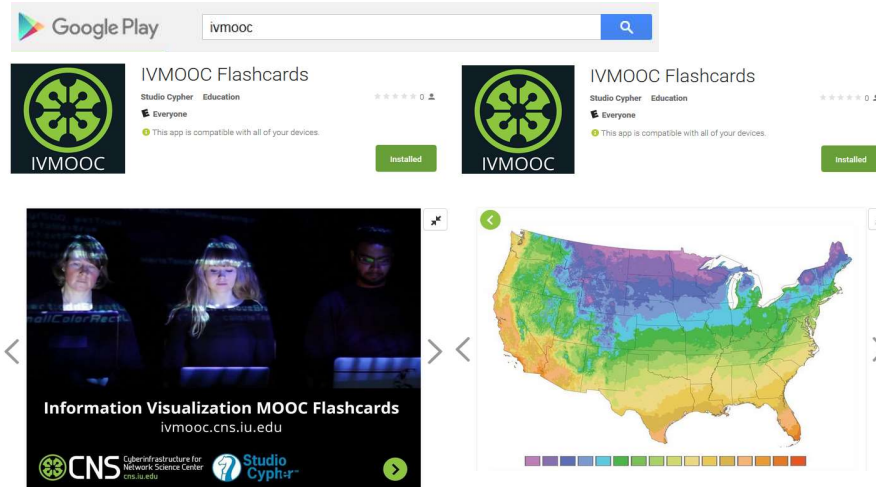
## Visualization Types (Reference Systems)

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 depend 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

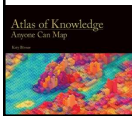
The “IVMOOC Flashcards” app can be downloaded from Google Play and Apple iOS stores.



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# Visualization Framework

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## Graphic Variable Types Versus Graphic Symbol Types


			Point	Line	Geometric Symbols
					Area
Spatial	x	quantitative			
	y	quantitative			
	z	quantitative			
Retinal	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			



Graphic Variable Types Versus Graphic Symbol Types

Variable Type	Symbol Type	Geometric Symbols				Alphabetic Symbols				Pictorial Symbols			
		point	line	area	volume	letter	number	initial	word	face	object	action	location
Color	Color												
Line	Line												
Area	Area												
Volume	Volume												
Letter	Letter												
Number	Number												
Initial	Initial												
Word	Word												
Face	Face												
Object	Object												
Action	Action												
Location	Location												

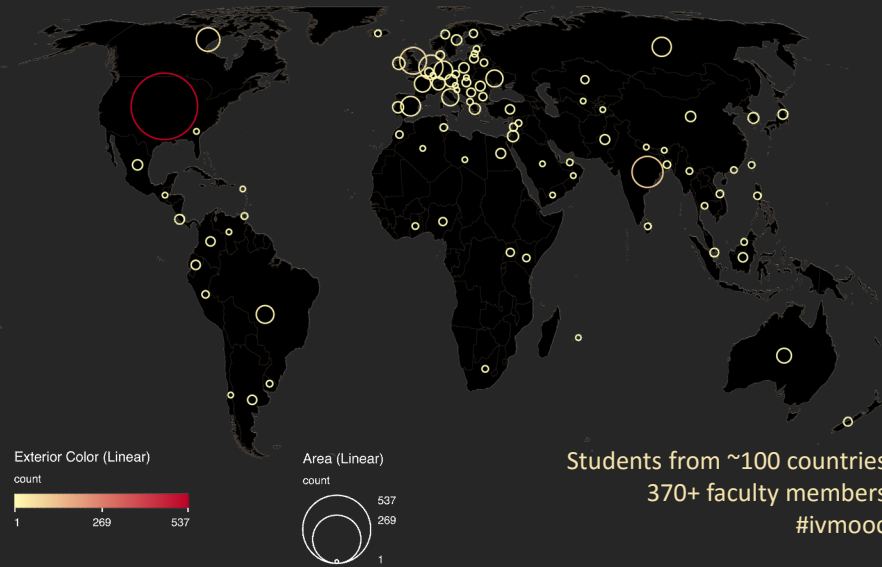

IVMOOC 2016
MENU



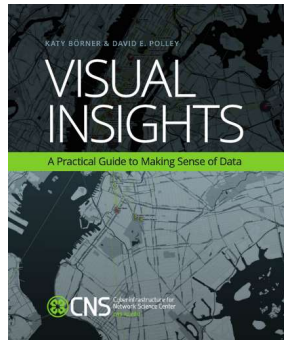
Information Visualization MOOC
ivmooc.cns.iu.edu

Register for free: <http://ivmooc.cns.iu.edu>. Class restarts Jan 10, 2017.

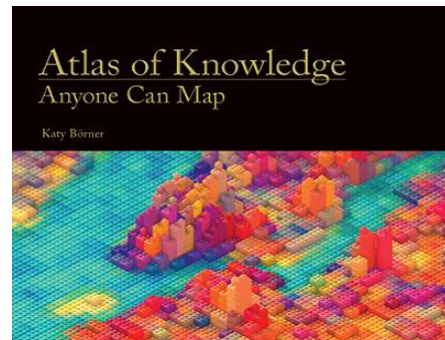
The Information Visualization MOOC  
ivmoo.cns.iu.edu



## 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.

## 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

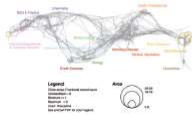


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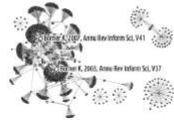
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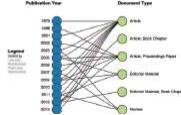
Topical Analysis—p. 56



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>

The screenshot displays the Sci2 Tool interface with several components visible:

- Console:** Shows the command history and output, including the selection of the 'Extract Co-Occurrence Network' and the 'Extract Co-Occurrence+Network' option.
- Data Manager:** Lists the loaded data files, such as 'ISI Data: C:\Users\Katy\Desktop\A-TOOLS\sci2-v1.1-b-361 Unique ISI Records'.
- Workflow Manager:** Shows the sequence of operations performed, including 'Extracted Co-Authorship Network' and 'Network with degree attribute: added to network'.
- Menu:** The 'Networks' menu is open, showing options like 'Extract Top Nodes', 'Extract Nodes Above or Below Value', 'Delete Isolates', and 'Extract Top Nodes'.
- Visualization:** The main area shows a network visualization, though it is partially obscured by the menu.

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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/](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>

Börner, Katy (2018) **Atlas of Forecasts: Predicting and Broadcasting Science, Technology, and Innovation**. The MIT Press.



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Put your money where your citations are: a proposal for a new funding system (website accessed 9/05/13)

**Upcoming Events**  
OCT 1 Katy Börner attends PLUG 2013 Northeast Conference  
10.13 Katy Börner presents Mapping Science Exhibit at WISE  
10.15 Ted Polley & Google Team present NMOOC at EDUCAUSE  
10.22 Katy Börner presents at the SciELO 13 Years Conference

**Development**  
Behind the scenes of the design and development of *AcademyScope*

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**Videos**  
Watch Katy Börner's full presentation from TEDxBloomington

**Teaching**  
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These slides will soon be at <http://cns.iu.edu/docs/presentations>  
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Mapping Science Exhibit Facebook: <http://www.facebook.com/mappingscience>

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