

Designing Effective Data Visualizations

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Indiana University, USA

Emory University
(Atwood Chemistry Center, Room 316)

February 4, 2016

Olivier H. Beauchesne, 2011. Map of Scientific Collaborations from 2005-2009.

Computed Using Data from Elsevier's Scopus

Map of Scientific Collaborations from 2005-2009

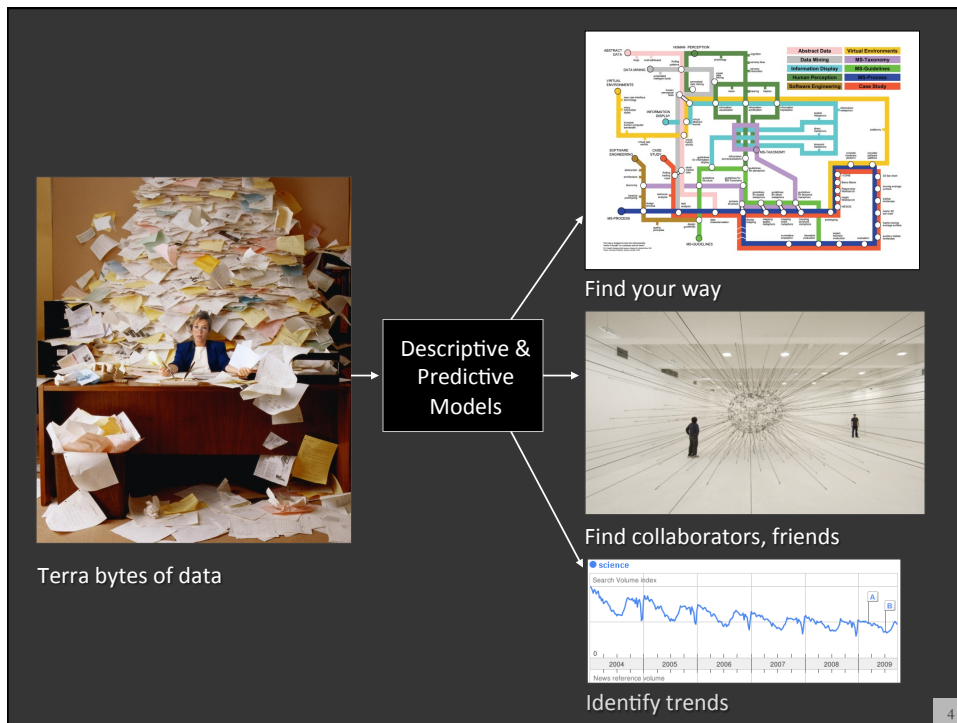


Olivier H. Beauchesne, 2011. Map of Scientific Collaborations from 2005-2009.

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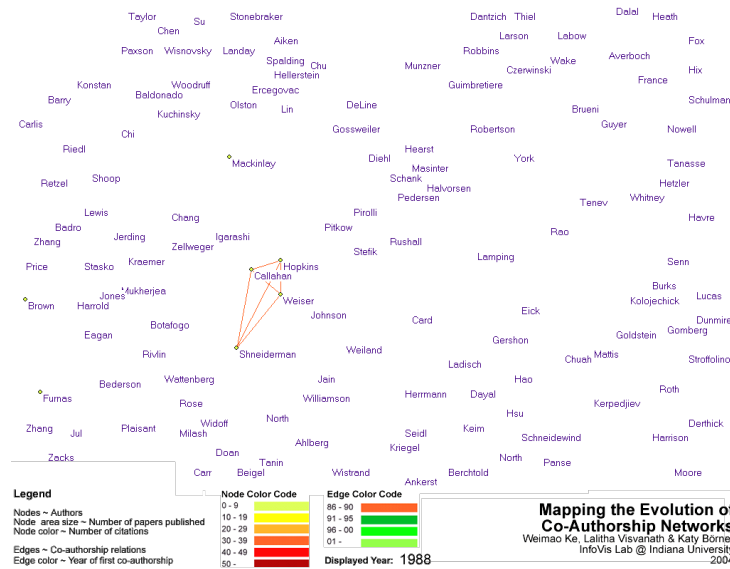
The Power of Data Visualizations

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Mapping the Evolution of Co-Authorship Networks

Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.

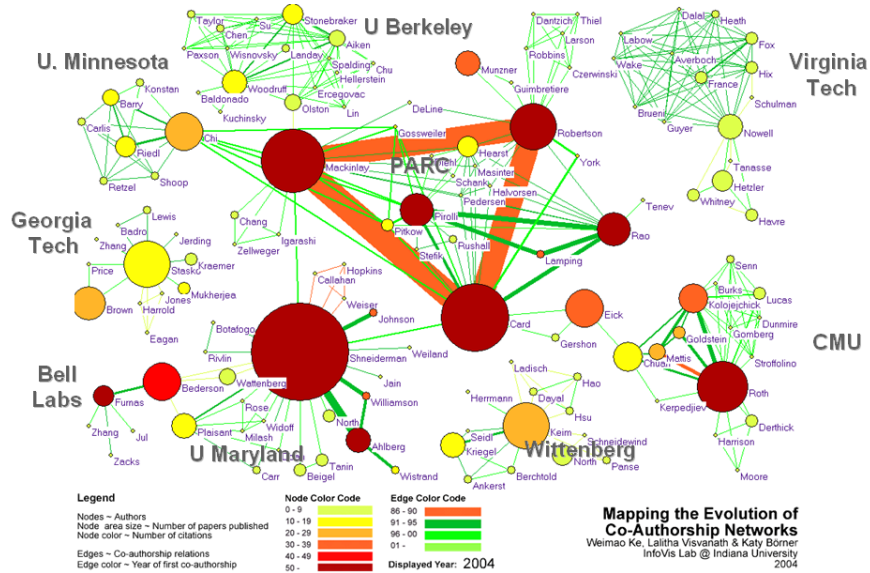


Mapping the Evolution of Co-Authorship Networks
Weimao Ke, Lalitha Visvanath & Katy Börner
InfoVis Lab @ Indiana University
2004

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Ke, Visvanath & Börner. 2004. Won 1st prize at the IEEE InfoVis Contest.

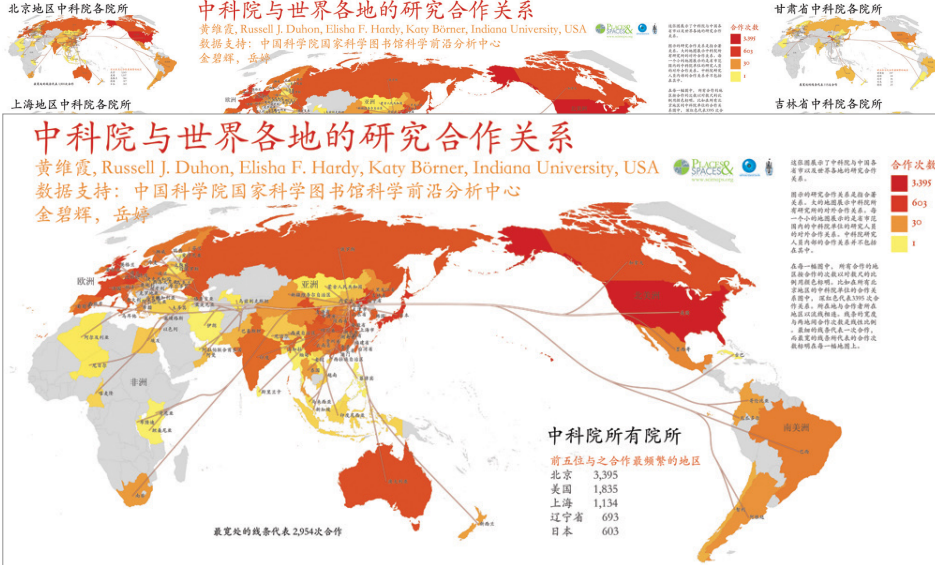


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Weimao Ke, Lalitha Visvanath & Katy Börner
InfoVis Lab @ Indiana University
2004

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Research Collaborations by the Chinese Academy of Sciences

Huang, Duhon, Hardy & Börner



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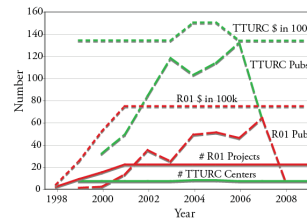
Mapping Transdisciplinary Tobacco Use Research Centers Publications

Compare R01 investigator-based funding with TTURC Center awards in terms of number of publications and evolving co-author networks.

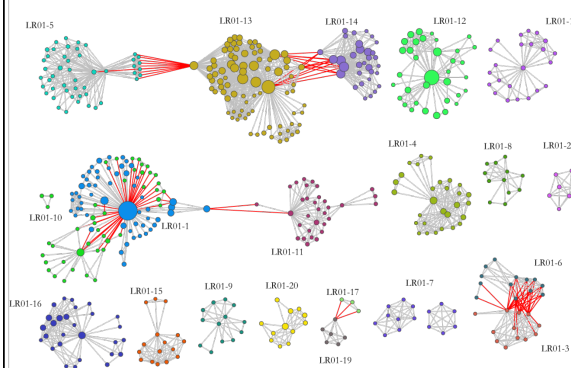
Stipelman, Hall, Zoss, Okamoto, Stokols, Börner, 2014.

Supported by NIH/NCI Contract HHSN261200800812

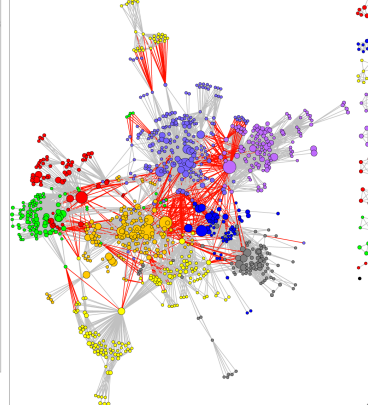
R01 & TTURC Project Information



Longitudinal R01 Co-Authorship Network



TTURC Co-Authorship Network



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The Global 'Scientific Food Web'

Mazloumian, Amin, Dirk Helbing, Sergi Lozano, Robert Light, and Katy Börner. 2013. "Global Multi-Level Analysis of the 'Scientific Food Web'". *Scientific Reports* 3, 1167. <http://cns.iu.edu/docs/publications/2013-mazloumian-food-web.pdf>

Contributions:

Comprehensive global analysis of scholarly knowledge production and diffusion on the level of continents, countries, and cities.

Quantifying knowledge flows between 2000 and 2009, we identify global sources and sinks of knowledge production. Our knowledge flow index reveals, where ideas are born and consumed, thereby defining a global 'scientific food web'.

While Asia is quickly catching up in terms of publications and citation rates, we find that its dependence on knowledge consumption has further increased.

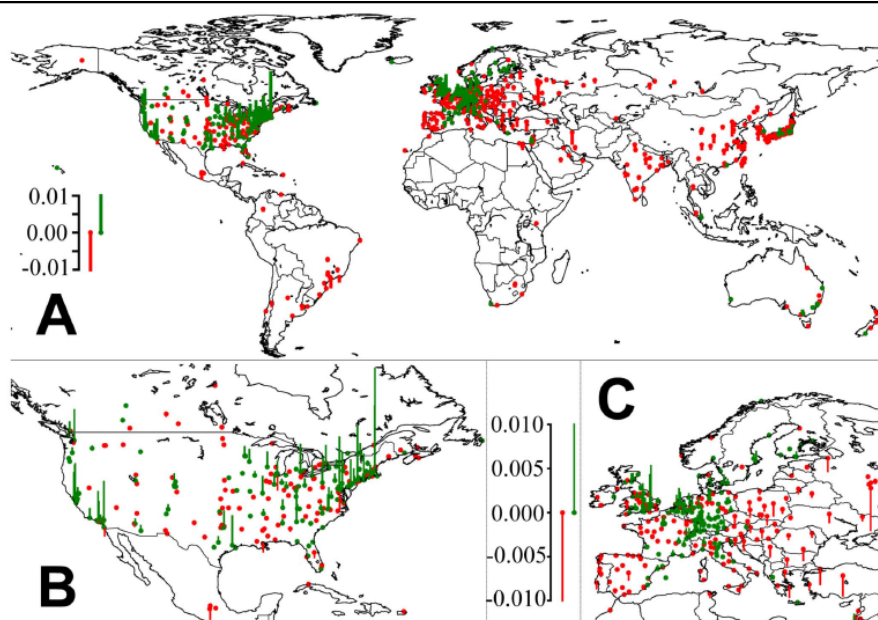
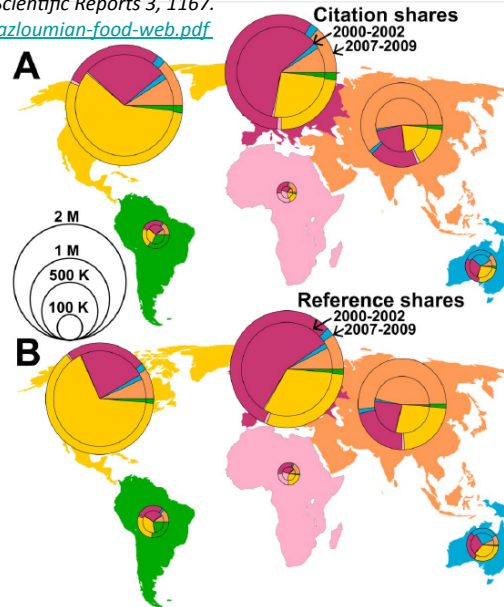
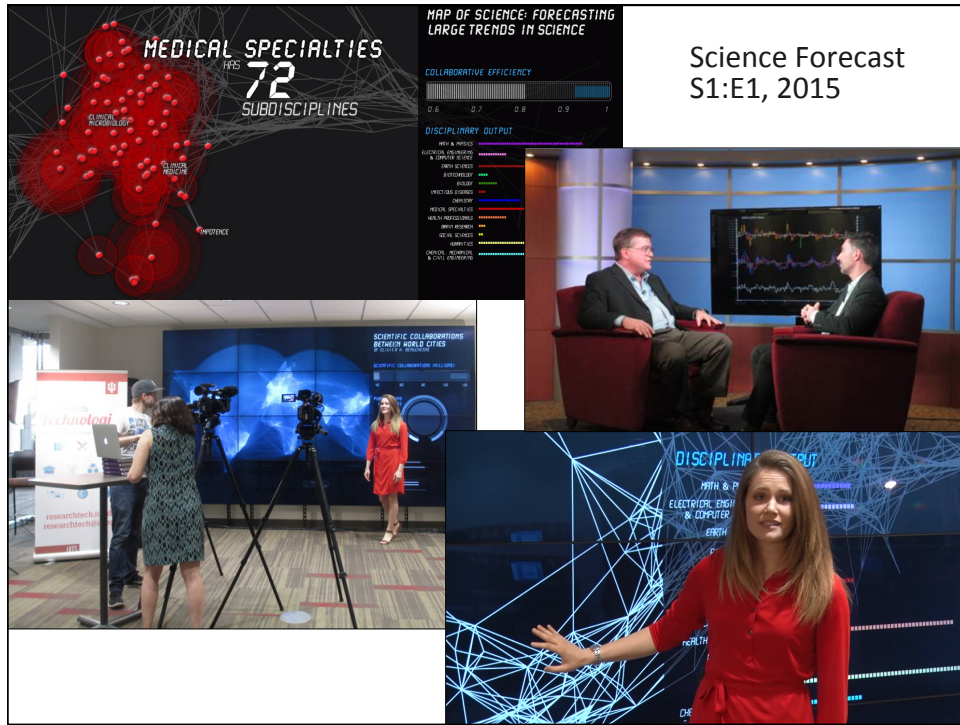
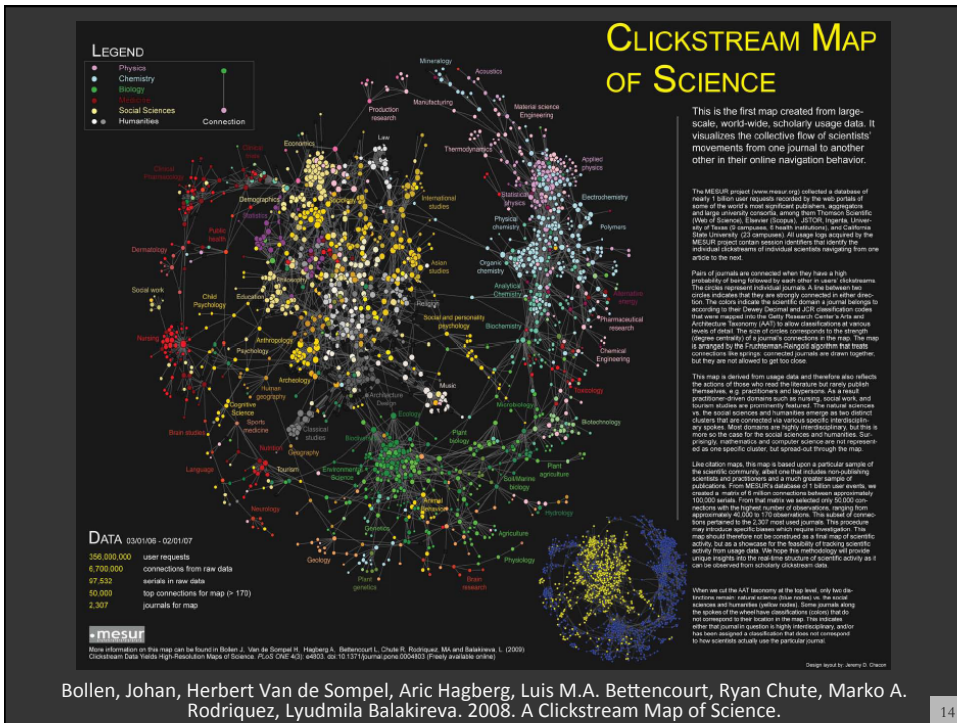
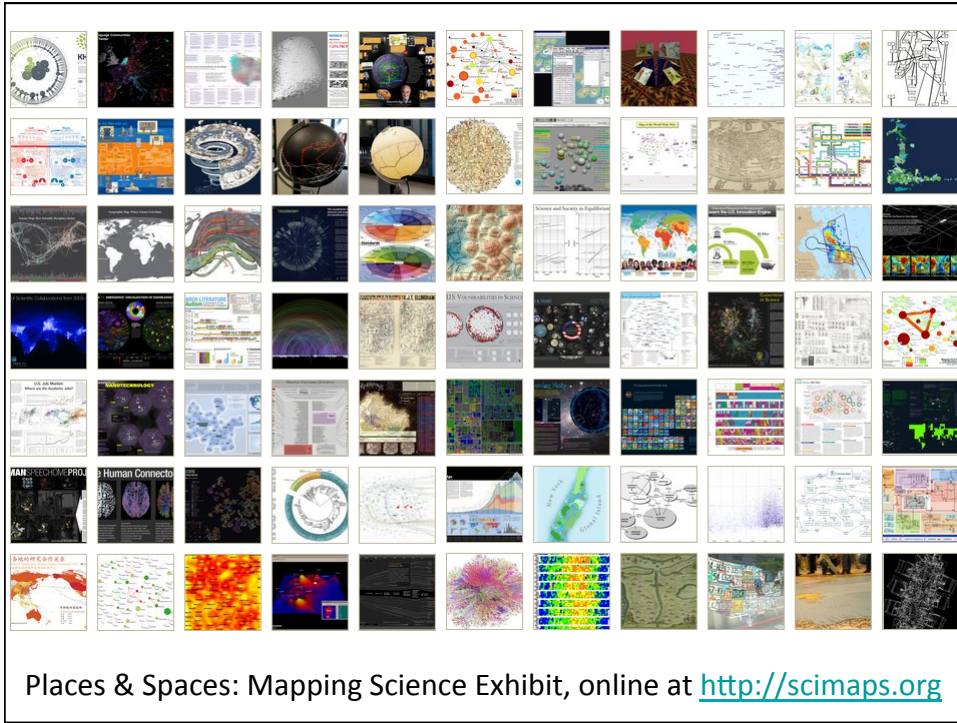
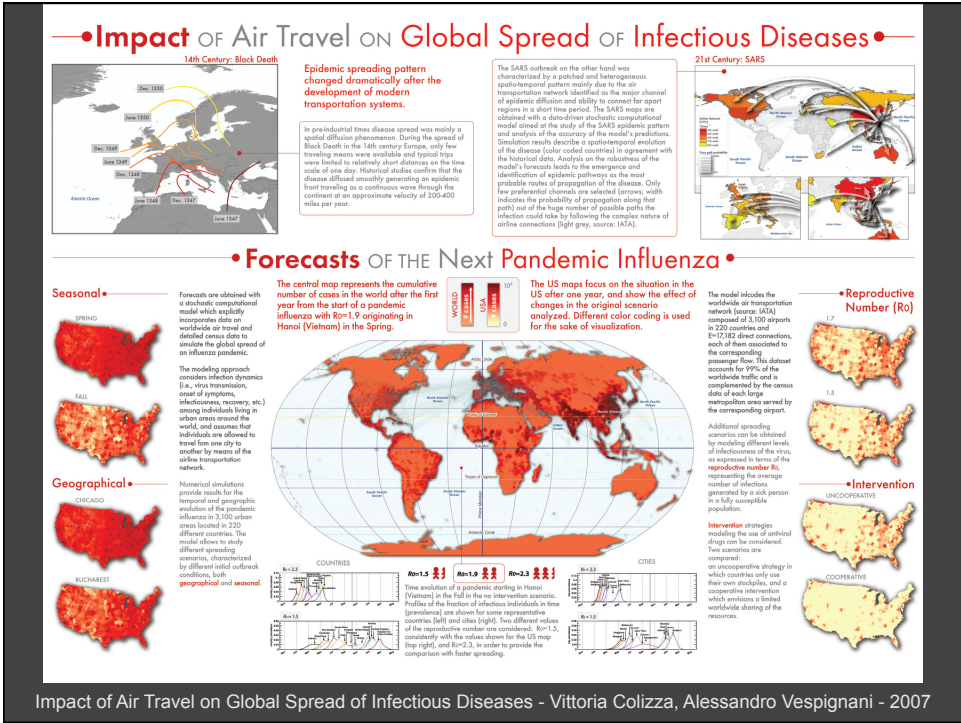


Figure 2 | World map of the greatest knowledge sources and sinks, based on our scientific fitness index. Green bars indicate that the number of citations received is over-proportional, red that the number of citations received is lower than expected (according to a homogeneous distribution of citations over all cities that have published more than 500 papers). It can be seen that most scientific activity occurs in the temperate zone. Moreover, areas of high fitness tend to be areas that are performing economically well (but the opposite does not hold).

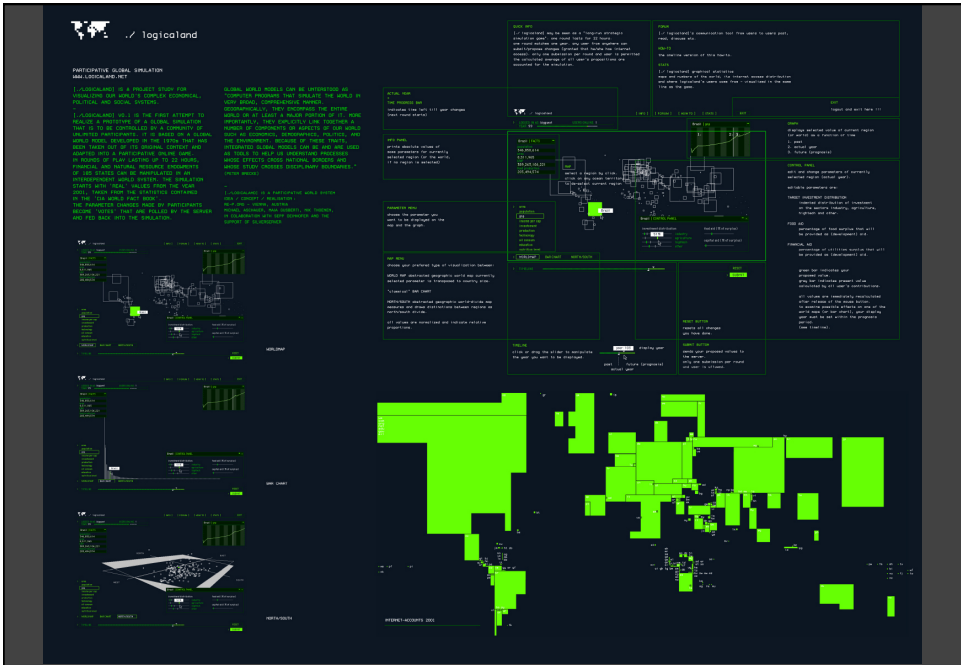
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Impact of Air Travel on Global Spread of Infectious Diseases - Vittoria Colizza, Alessandro Vespignani - 2007



Logiland Participative Global Simulation - Michael Ashauer, Maia Gusberti, Nik Thoenen - 2002




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

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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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Geographic Map: Where Science Gets Done

Science Map: How Scientific Disciplines Relate

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 - 2,431
- Africa - 2,208
- South America - 1,562

Top Five Scientific Disciplines

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

Input your search query here.

Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	"
Z	X	C	V	B	N	M			
Space									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

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Geographic Map: Where Science Gets Done

Science Map: How Scientific Disciplines Relate

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About

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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 regulation by central authorities or privatization.

<http://scimaps.org>

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

Keyword Search

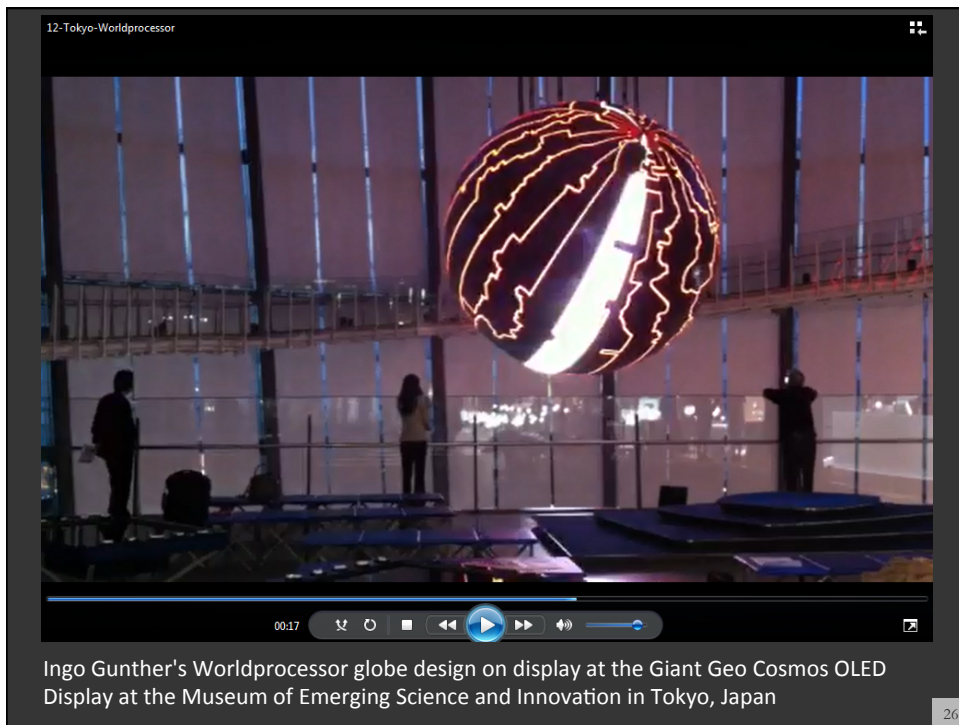
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Science Maps in "Expedition Zukunft" science train visiting 62 cities in 7 months 12 coaches, 300 m long Opening was on April 23rd, 2009 by German Chancellor Merkel




<http://www.expedition-zukunft.de>

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Hidalgo, César A., Bailey Kilger, 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 (2015)

<http://scimaps.org/call>

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
- 16th Iteration (2020): Macroscopes for Scholars

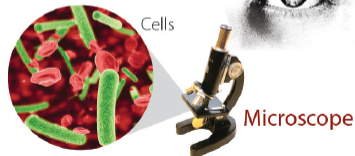
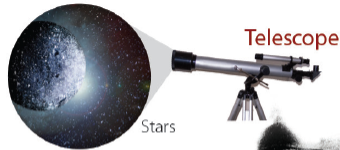
27

Plug-and-Play Macroscopes

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Microscopes, Telescopes, Macroscopes

The Infinitely Great



The Infinitely Small

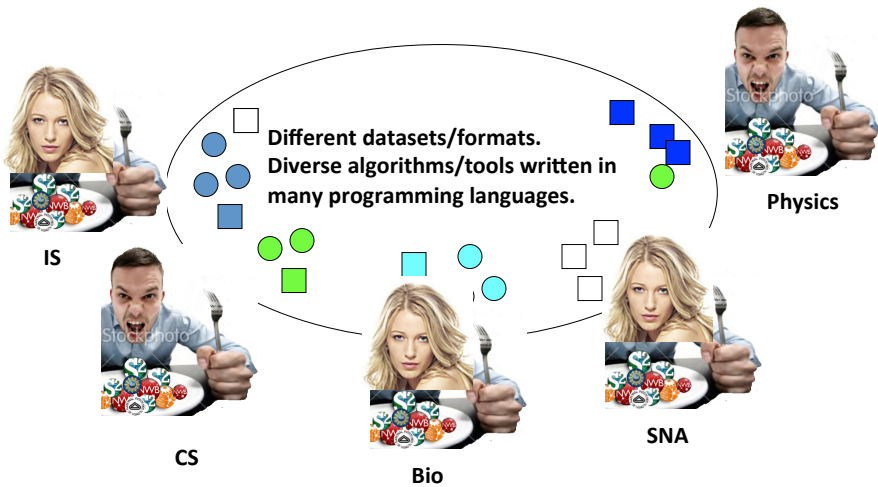


The Infinitely Complex



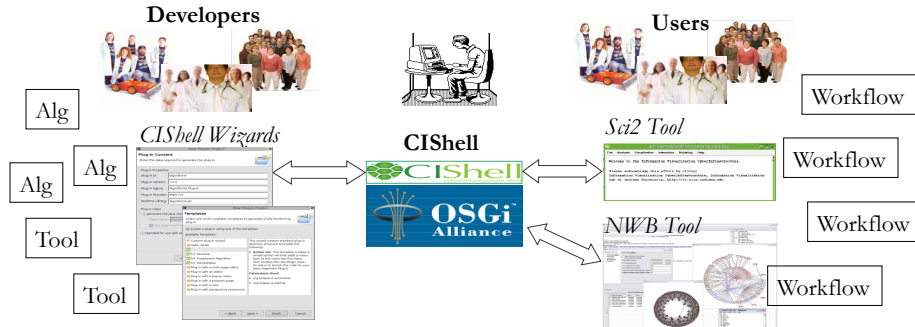
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Plug-and-Play Macroscopes

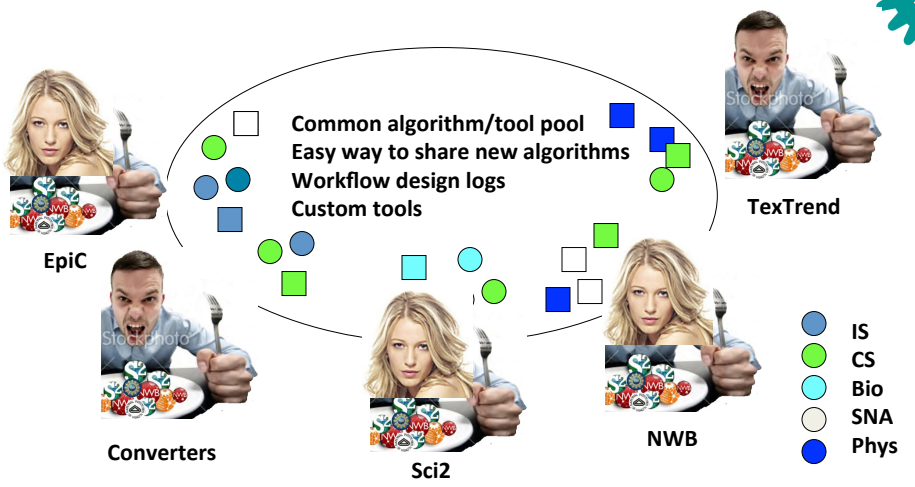


30

Plug-and-Play Macroscopes






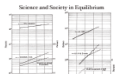



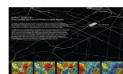
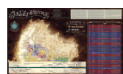









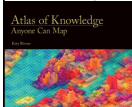
Plug-and-Play Macroscopes



Information Visualization Framework & IVMOOC

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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 105	 Productivity life sciences research page 105	 Science and Society in Equalization Number of scientists versus population and R&D costs versus GNP page 105
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 109	 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 Jerome Lemelson page 89	 Evolving journal networks in nanotechnology page 139	 Product space showing co-export patterns of countries page 95
WITH WHOM: Network Analysis page 60	 World Finance Corporation network page 87	 Electronic and new media art page 153	 World-wide scholarship collaboration networks page 127

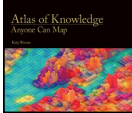


See page 5

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



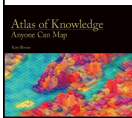
See page 24

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

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

			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

		Geometric Symbols				Alphabetic Symbols				Pictorial Symbols			
		point	line	area	surface	volume	text, Numerals, Punctuation Marks	text, Numerals, Punctuation Marks	text, Numerals, Punctuation Marks	text, Numerals, Punctuation Marks	images, Icons, Subtitled Graphs	images, Icons, Subtitled Graphs	images, Icons, Subtitled Graphs
FORM	size												
	shape												
	orientation												
	curvature												
	angle												
	closure												
	value												
	color												
	saturation												
	opacity												
TEXTURE	consistency												
	randomness												
	conservation												
	closure												
	flat												
	irregularity												
	repeating												
	irregularity length												
	spaced												
	velocity												
MOTION	direction												
	velocity												

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IVMOOC 2016

MENU



Information Visualization MOOC
ivmooc.cns.iu.edu

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

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

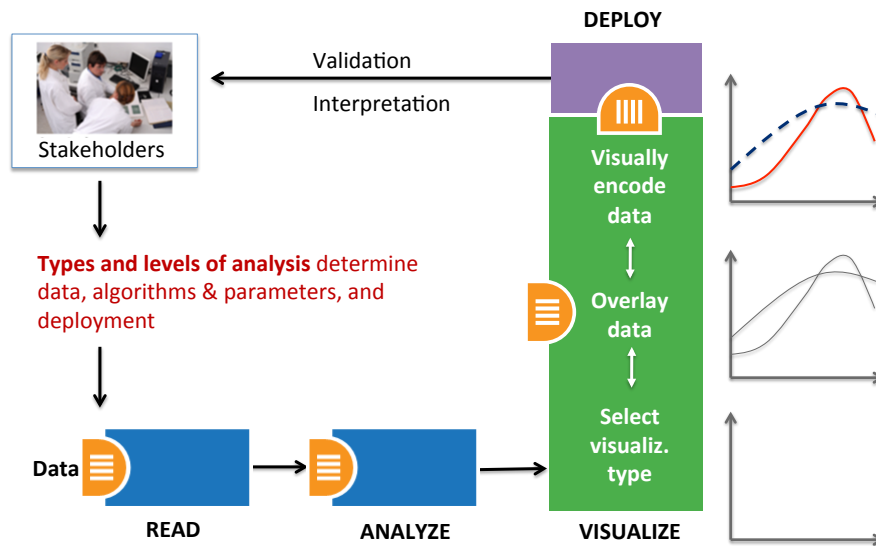
Part 2: Students work in teams on client projects.

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

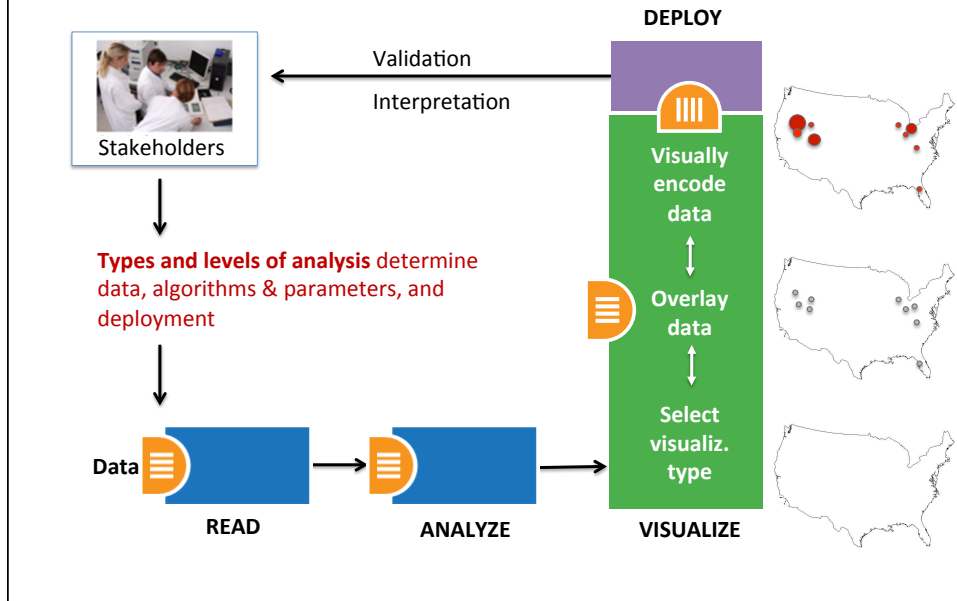


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Needs-Driven Workflow Design



Needs-Driven Workflow Design

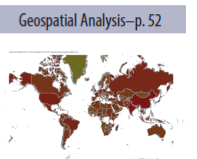
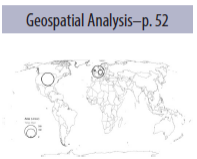
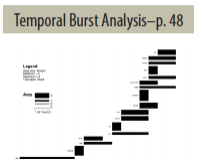


Load **One** File and Run **Many** Analyses and Visualizations

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

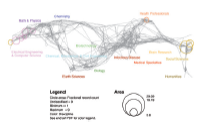
Location	Count	# Citations
Netherlands	13	292
United States	9	318
Germany	11	36
United Kingdom	1	2



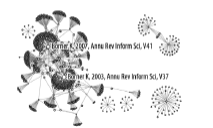
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13	2010	WASHINGTON	USA	SCIENCE TRANSLATIONAL MEDICINE	A Multi-Level Systems Perspective for the Science of Team Science	Cell Biology Research & Experimental Medicine	Borner, K Contractor, N Falk-Krzesinski, HJ Fiore, SM Hall, KL Keyton, J Spring, B 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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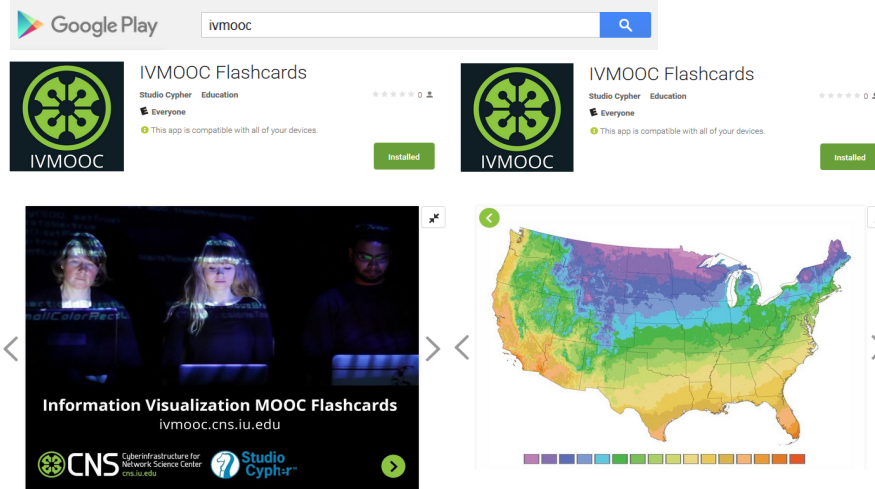
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IVMOOC App – More than 60 visualizations

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



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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>

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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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