

(Network) Data Visualization Literacy

Katy Börner @katycns

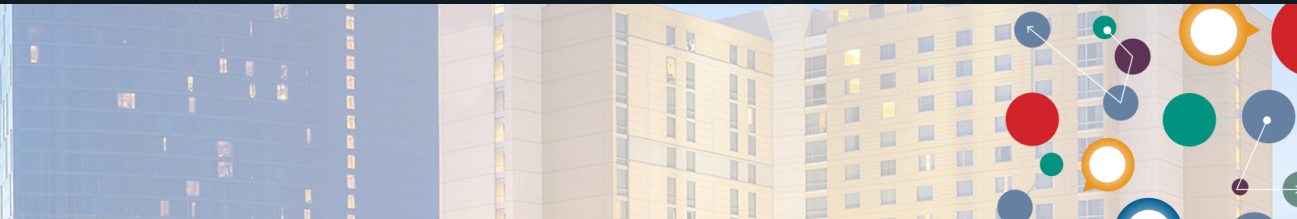
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Intelligent Systems Engineering & Information Science
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School of Informatics and Computing
Indiana University Network Science Institute
Indiana University, USA

*NetSciEd6, NetSci Conferences, Indianapolis, IN
June 20, 2017*



Indianapolis, Indiana
June 19 - 23, 2017

International School and Conference on Network Science
Conference Agenda Manager

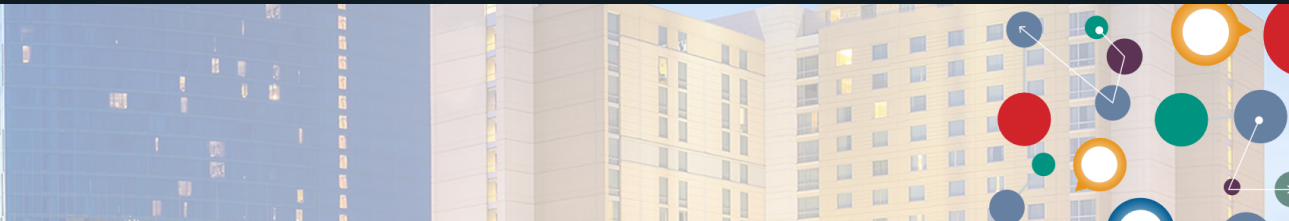


Data Visualization Literacy: Definition



Indianapolis, Indiana
June 19 - 23, 2017

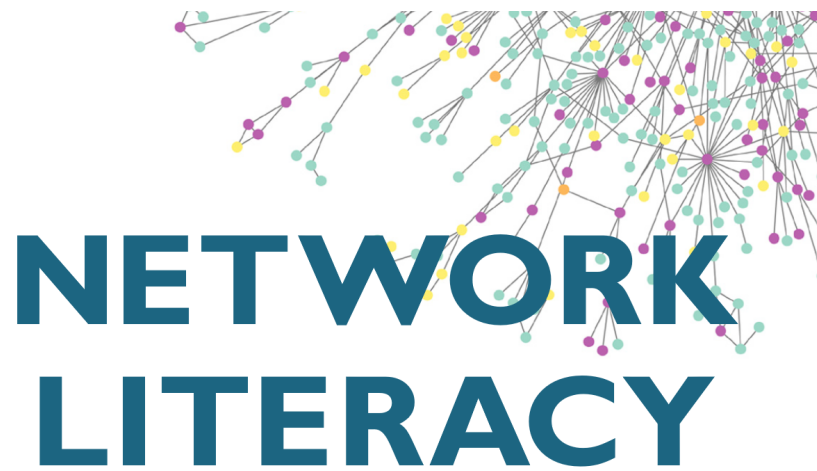
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Data Visualization Literacy

Data visualization literacy (ability to read, make, and explain data visualizations) requires

- *literacy* (ability to read and write text, e.g., in titles, axis labels, legend),
- *visual literacy* (ability to find, interpret, evaluate, use, and create images and visual media), and
- *data literacy* (ability to read, create, and communicate data).



Essential Concepts and Core Ideas

Network Visualization Literacy: Novel Approaches to Measurement and Instruction

Angela Zoss, Duke University

Adam Maltese, Indiana University

Stephen Uzzo, New York Hall of Science

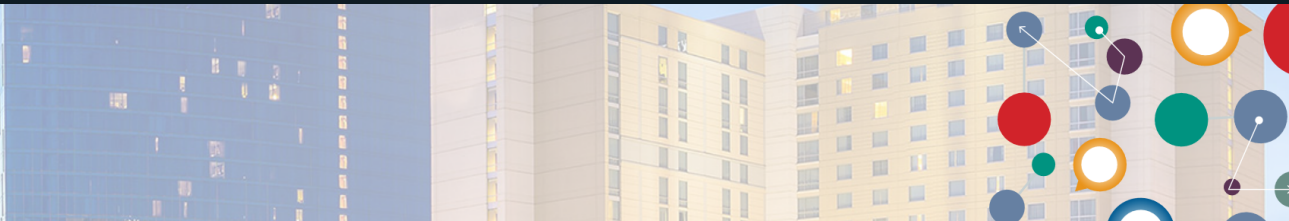
Katy Börner, Indiana University

Data Visualization Literacy: Teaching



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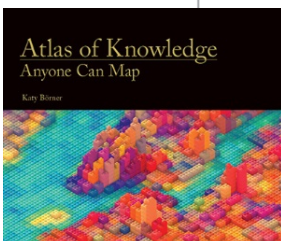
Register for free: <http://ivmooc.cns.iu.edu>. Class starts again Jan 9, 2017.

Tasks

LEVELS

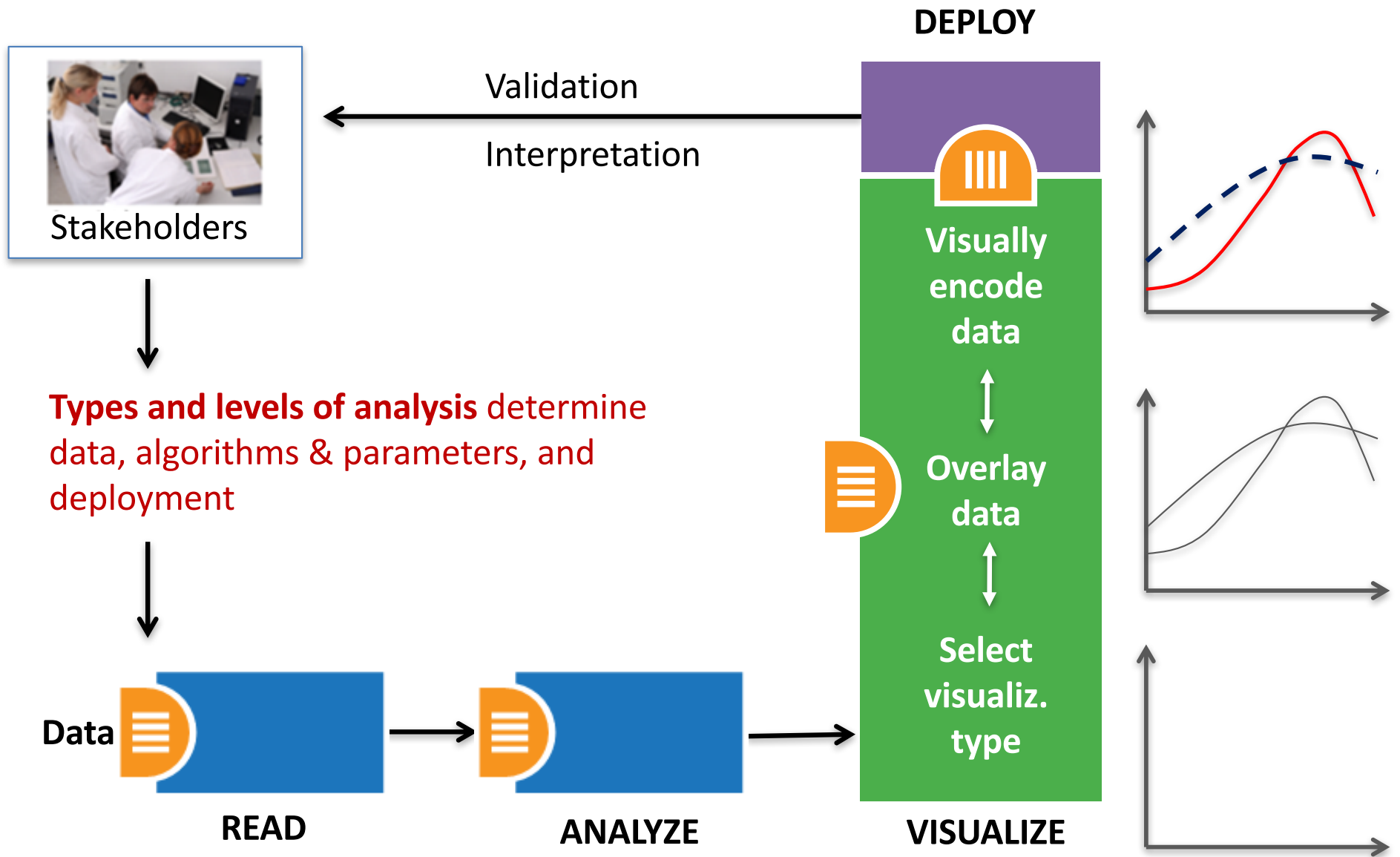
TYPES

	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 
Statistical Analysis page 44 	 Knowledge Cartography page 135	 Productivity of Russian life sciences research teams page 105	Science and Society in Equilibrium  Number of scientists versus population and R&D costs versus GNP. page 103
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 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 157



See page 5

Needs-Driven Workflow Design



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

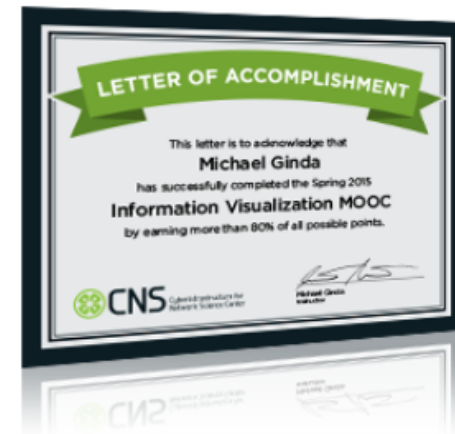
Mid-Term

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

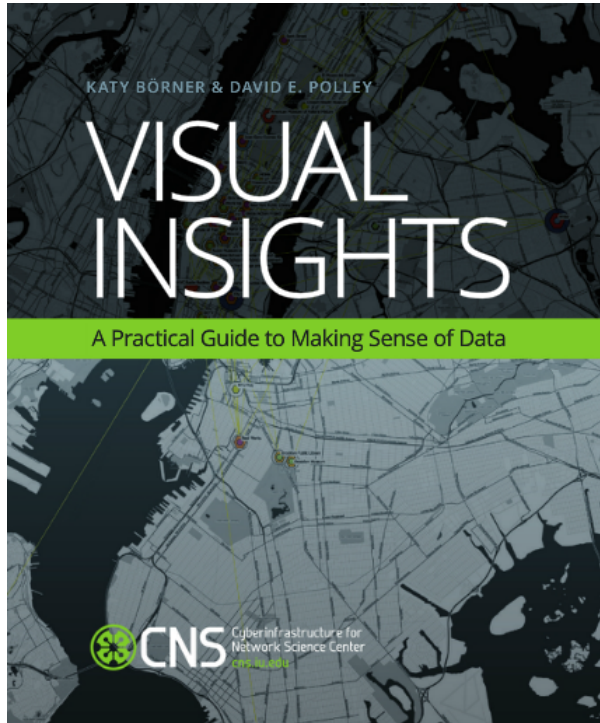
Final Exam

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%).

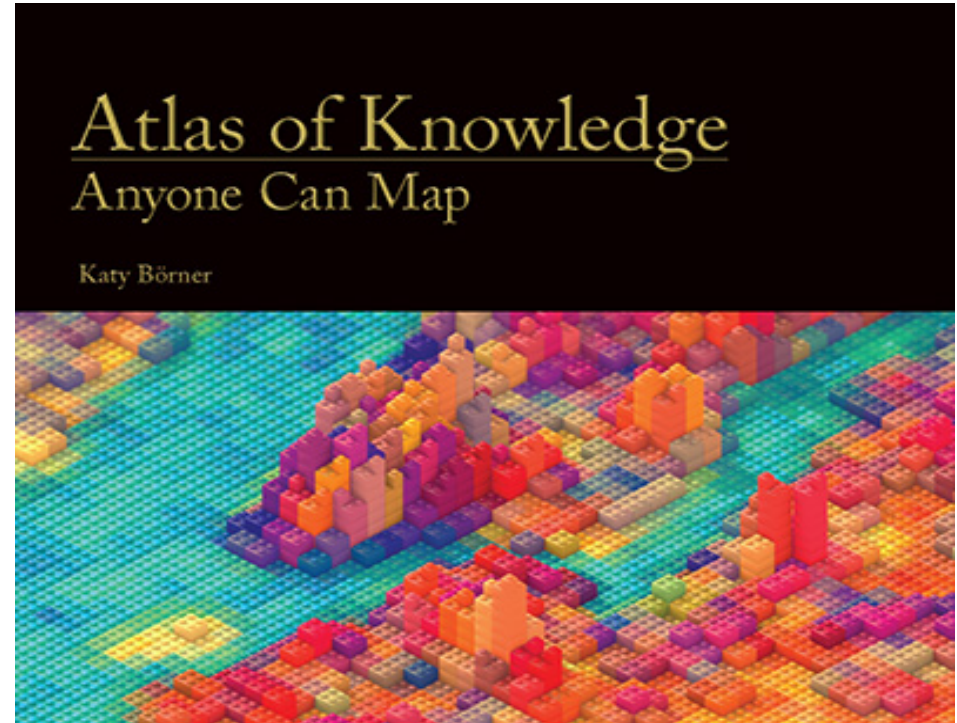


Books Used in the IVMOOC



Teaches timely knowledge:

Advanced algorithms, tools, and hands-on workflows.



Teaches timeless knowledge:

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

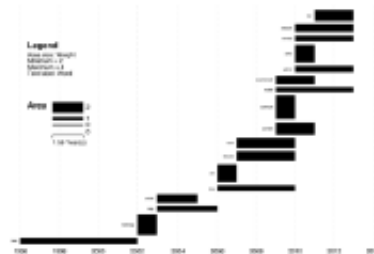
Load **One** File and Run **Many** Analyses and Visualizations

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

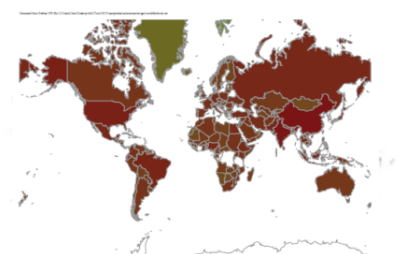
Temporal Burst Analysis—p. 48



Geospatial Analysis—p. 52



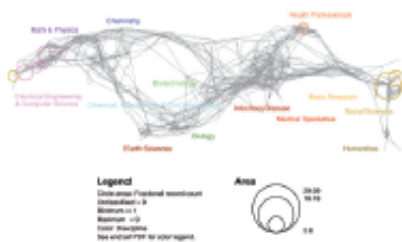
Geospatial Analysis—p. 52



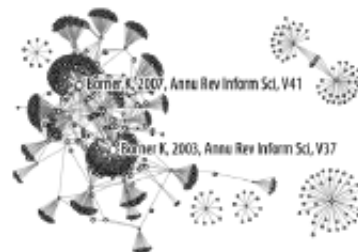
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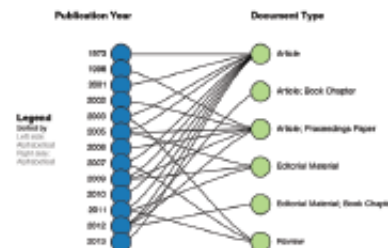
Topical Analysis—p. 56



Paper Citation Network—p. 60



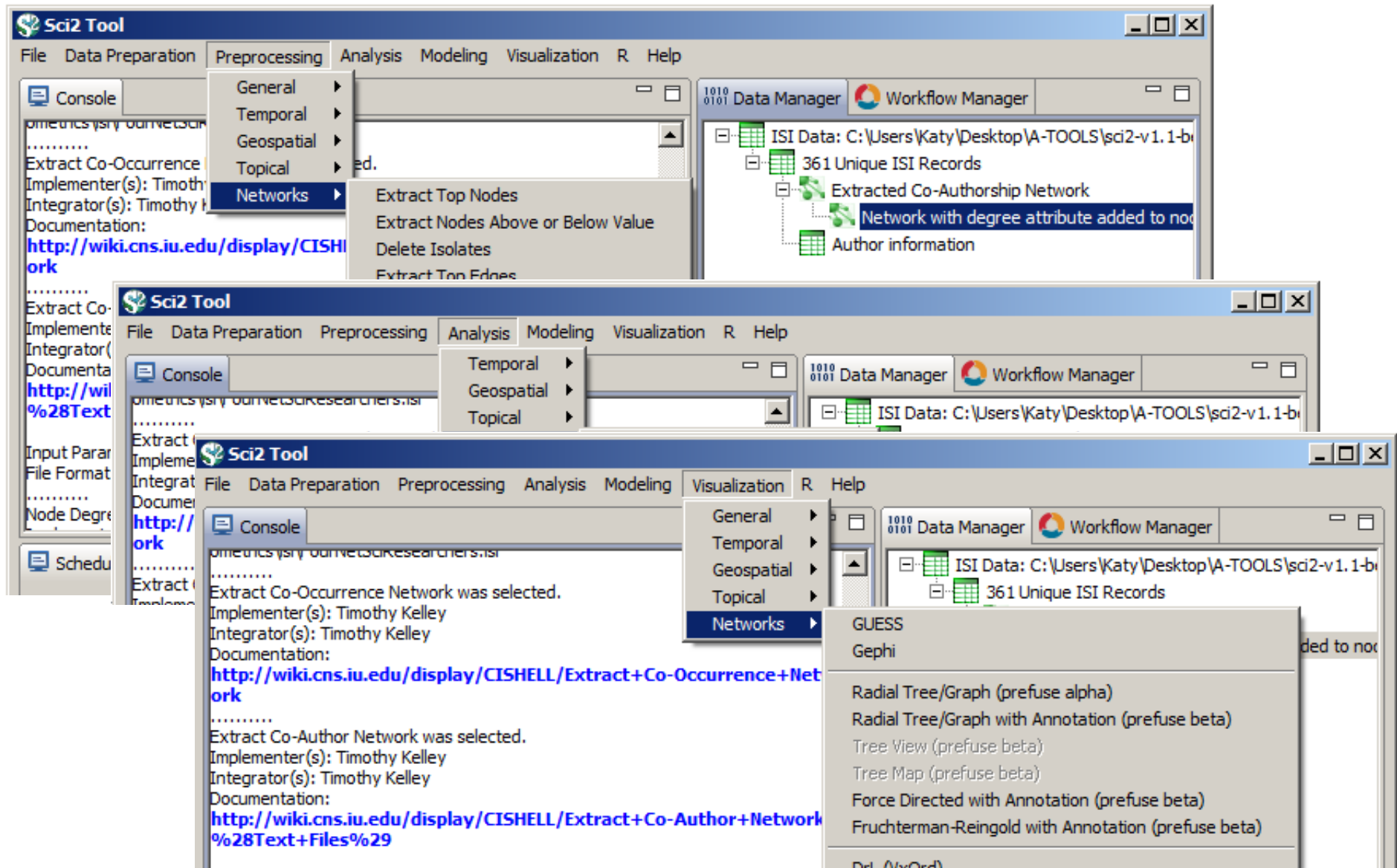
Bi-Modal Network—p. 60



Co-author and many other bi-modal networks.

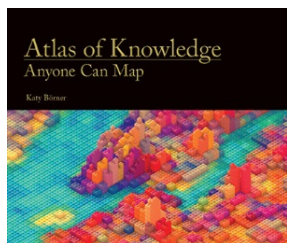
Sci2 Tool Interface Components

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



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



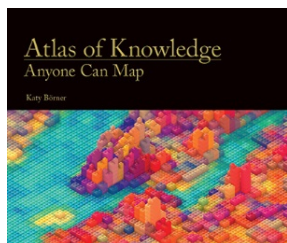
See page 24

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

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See page 24

Graphic Variable Types Versus Graphic Symbol Types

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

Graphic Variable Types Versus Graphic Symbol Types

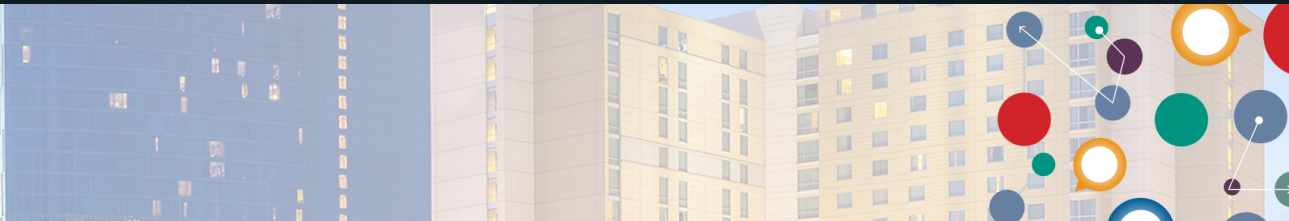
		Geometric Symbols						Linguistic Symbols Text, Numerals, Punctuation Marks		Pictorial Symbols Images, Icons, Statistical Glyphs	
		Point	Line	Area	Surface	Volume					
Labels	1										
	2										
	3										
Form	size	NA (Not Applicable)									
	shape	NA									
	rotation	NA									
	curvature	NA									
	angle	NA									
	closure	NA									
	value										
	hue										
Color	saturation										
	value										
	hue										
Texture	spacing										
	constancy										
	pattern										
	orientation	NA									
	gradient										
	blur										
	transparency										
	shading										
	stereoscopic depth	Point in foreground - background	Line in foreground - background	Area in foreground - background	Surface in foreground - background	Volume in foreground - background	Text in foreground - background	Text in foreground - background	Icons in foreground - background	Icons in foreground - background	
	Motion	speed									
velocity											
style		Blinking point slow - fast	Blinking line slow - fast	Blinking area slow - fast	Blinking surface slow - fast	Blinking volume slow - fast	Blinking text slow - fast	Blinking text slow - fast	Blinking icons slow - fast	Blinking icons slow - fast	

Data Visualization Literacy: Research



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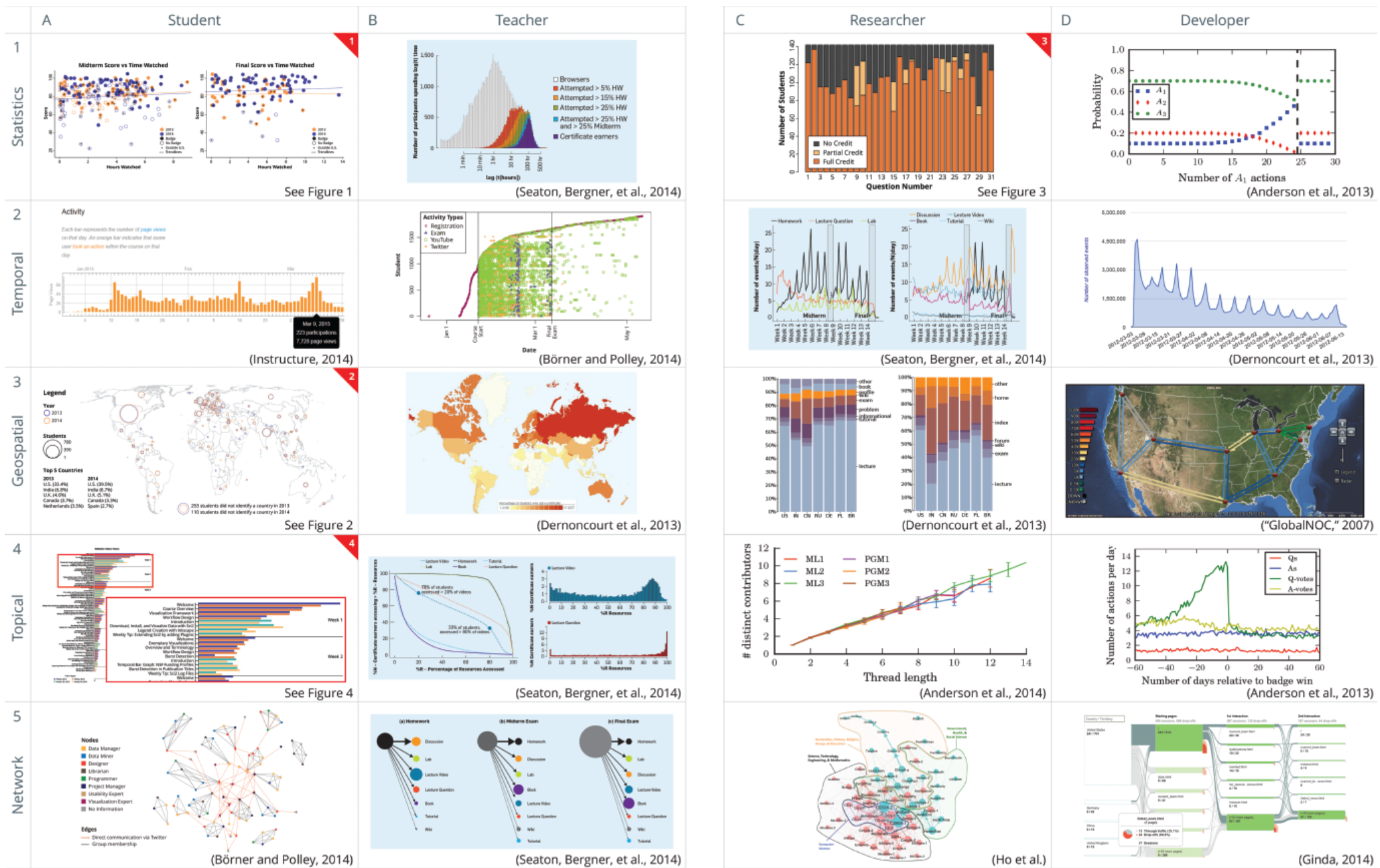


Figure 1: Analysis types vs. user needs, taken from

Emmons, Light, and Börner. ["MOOC Visual Analytics: Empowering Teachers, Students, Researchers, and Developers of Massively Open Online Courses"](#). *Journal of the Association for Information Science and Technology* (in press).

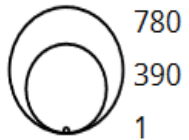
Students' Countries

Legend

Year



Students



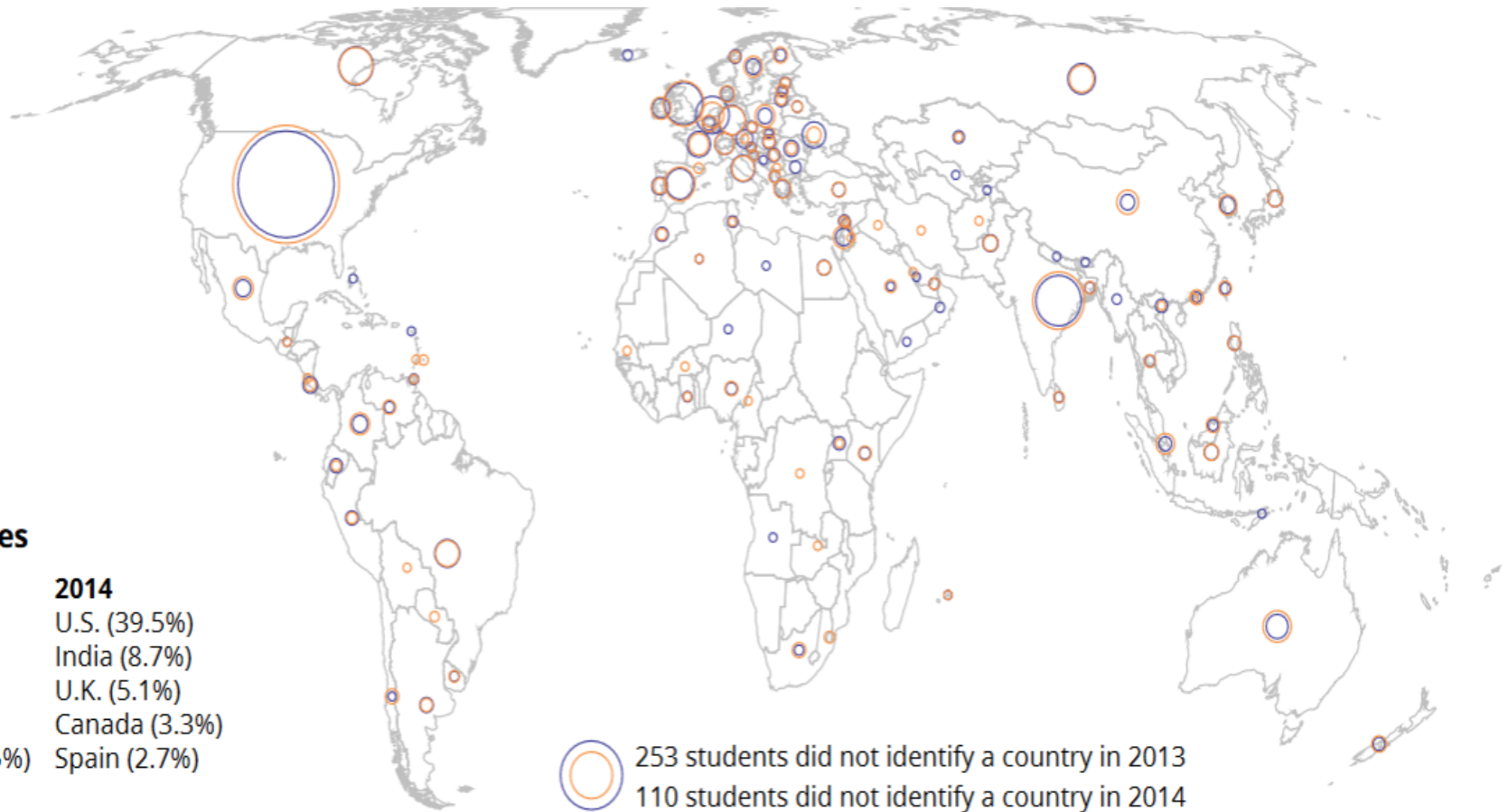
Top 5 Countries

2013

U.S. (33.4%)
 India (6.8%)
 U.K. (4.6%)
 Canada (3.7%)
 Netherlands (3.5%)

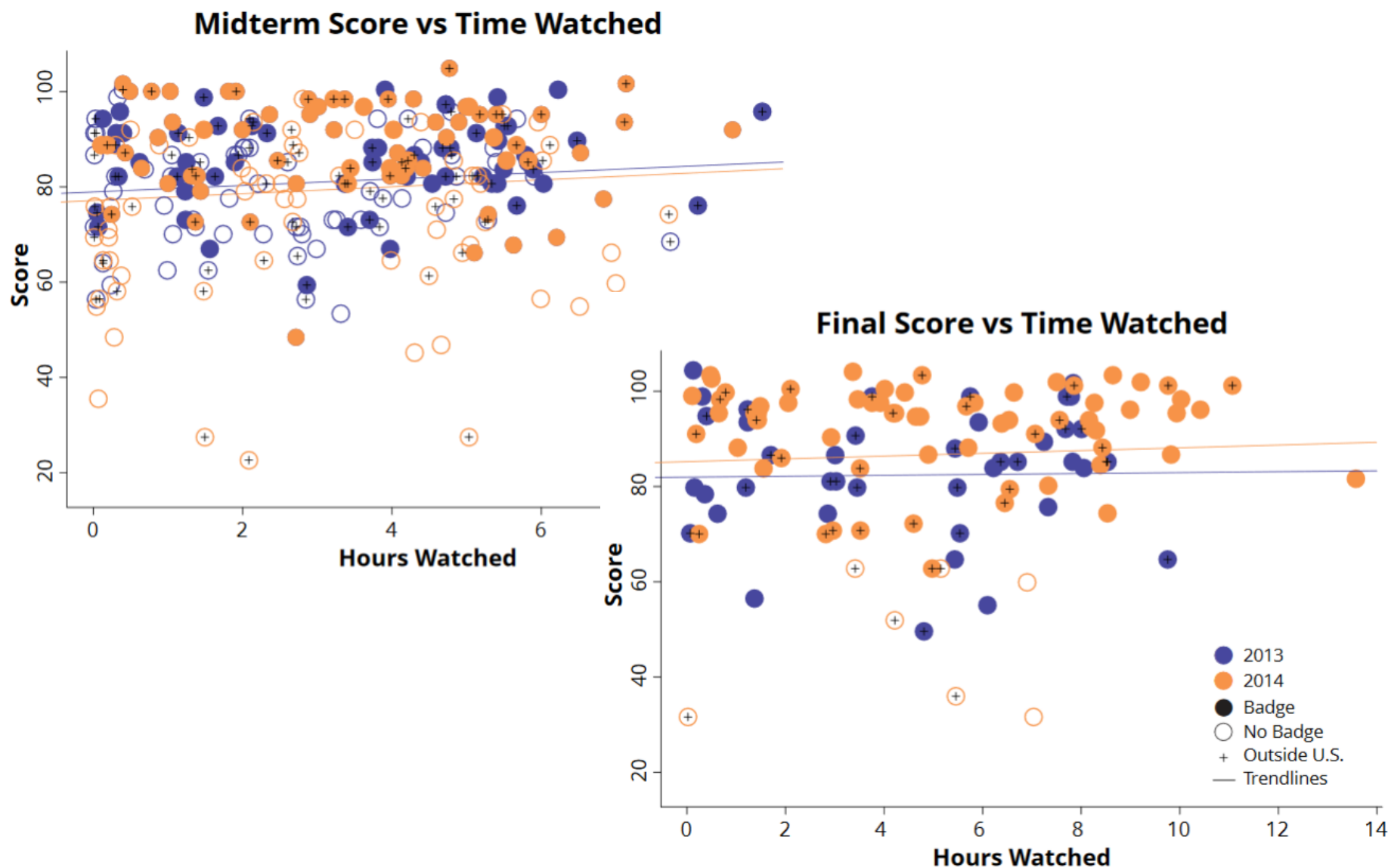
2014

U.S. (39.5%)
 India (8.7%)
 U.K. (5.1%)
 Canada (3.3%)
 Spain (2.7%)



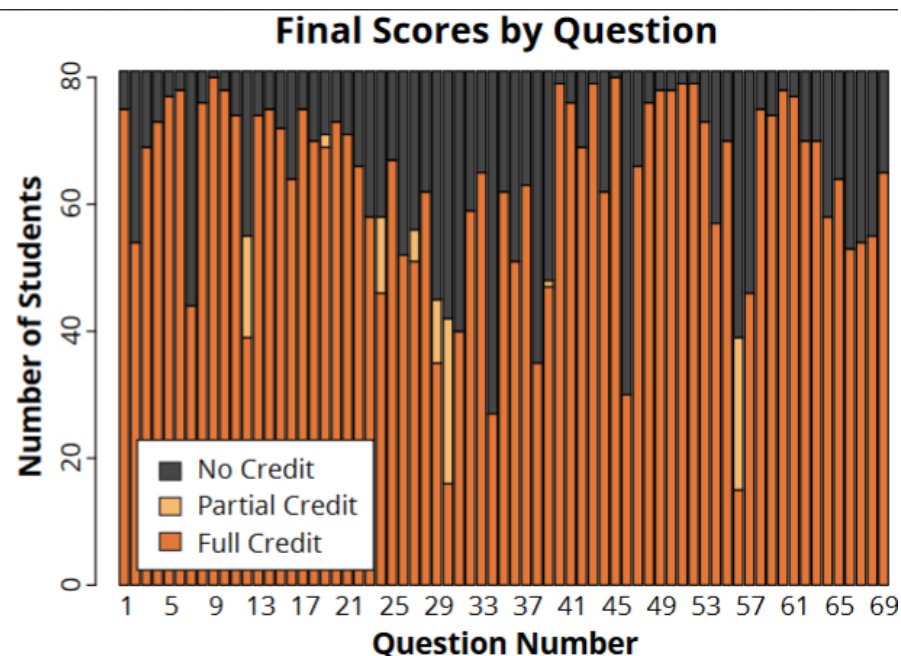
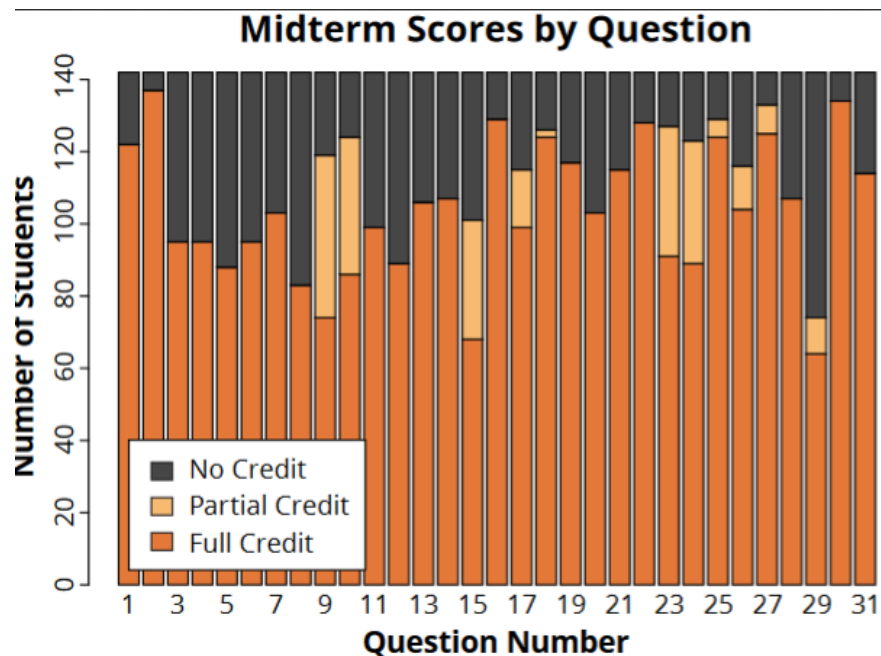
Proportional symbol map of the world showing the location of IVMOOC students from 2013 (blue) and 2014 (orange). Circles are area size coded by the number of students per country.

Student Final Score vs. Hours Watched

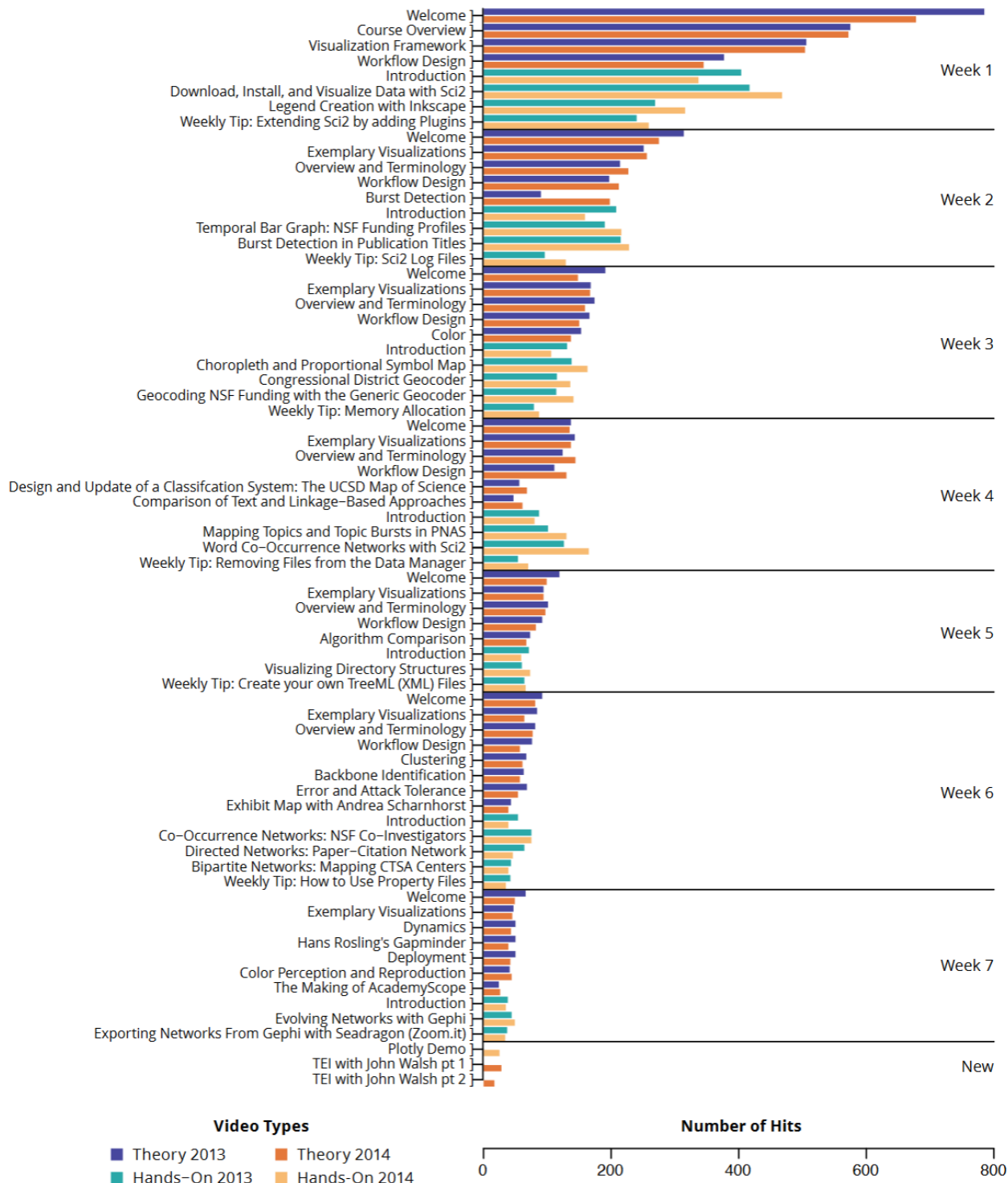


Scores vs. time invested watching course videos for students who took the 2013 (blue) and 2014 (orange) IVMOOC midterm (left) and final exam (right) and got at least 50% correct.

Exam Scores by Question



Student scores per question for midterm (left) and final exam (right) for IVMOOC 2014.



IVMOOC Video Views

IVMOOC video views in 2013 (blue) and 2014 (orange)

Student Client Projects: All Interactions



Student Engagement and Performance

Learning Analytics

IVMOOC 2015 Student Group Engagement and Scores

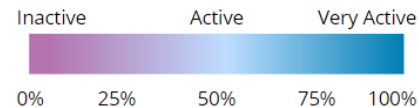
	Pre-Course	Week 1	Week 2	Week 3	Week 4	Midterm	Week 5	Week 6	Week 7	Week 8	Week 9	Final	Curr. Score
IVMOOC	26.05%	38.32%	31.32%	29.96%	27.1%	28.34%	31.07%	24.28%	16.86%	18.23%	13.08%	13.41%	20.87%
Z637-29374	33.01%	52.91%	49.89%	59.22%	50.89%	82.56%	65.04%	49.99%	39.59%	61.63%	54.91%	82.25%	82.4%
Z637-32593	25.08%	54.54%	43.58%	50.67%	53.63%	77.67%	65.7%	59.48%	52.19%	65.71%	47.27%	72.59%	75.13%
Z637-33781	29.33%	55.38%	49.26%	62.18%	77.47%	85%	87.4%	69.8%	55.56%	57.6%	45.69%	70.89%	77.94%

IVMOOC 2015 Student Group Engagement for Midterm

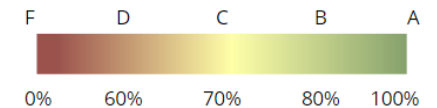
	Midterm	Final	Curr. Score	Overall Engagemer
Student 198	100%	85.33%	92.67%	30.34%
Student 210	100%	84%	92%	33.91%
Student 242	97.14%	98.67%	97.9%	55.89%
Student 265	95.71%	92%	93.86%	82.64%
Student 216	95.71%	24%	59.86%	34.92%
Student 257	94.29%	98.67%	96.48%	68.25%
Student 264	94.29%	89.33%	91.81%	80.47%
Student 262	94.29%	85.33%	89.81%	79.65%

Legends

Engagement



Score

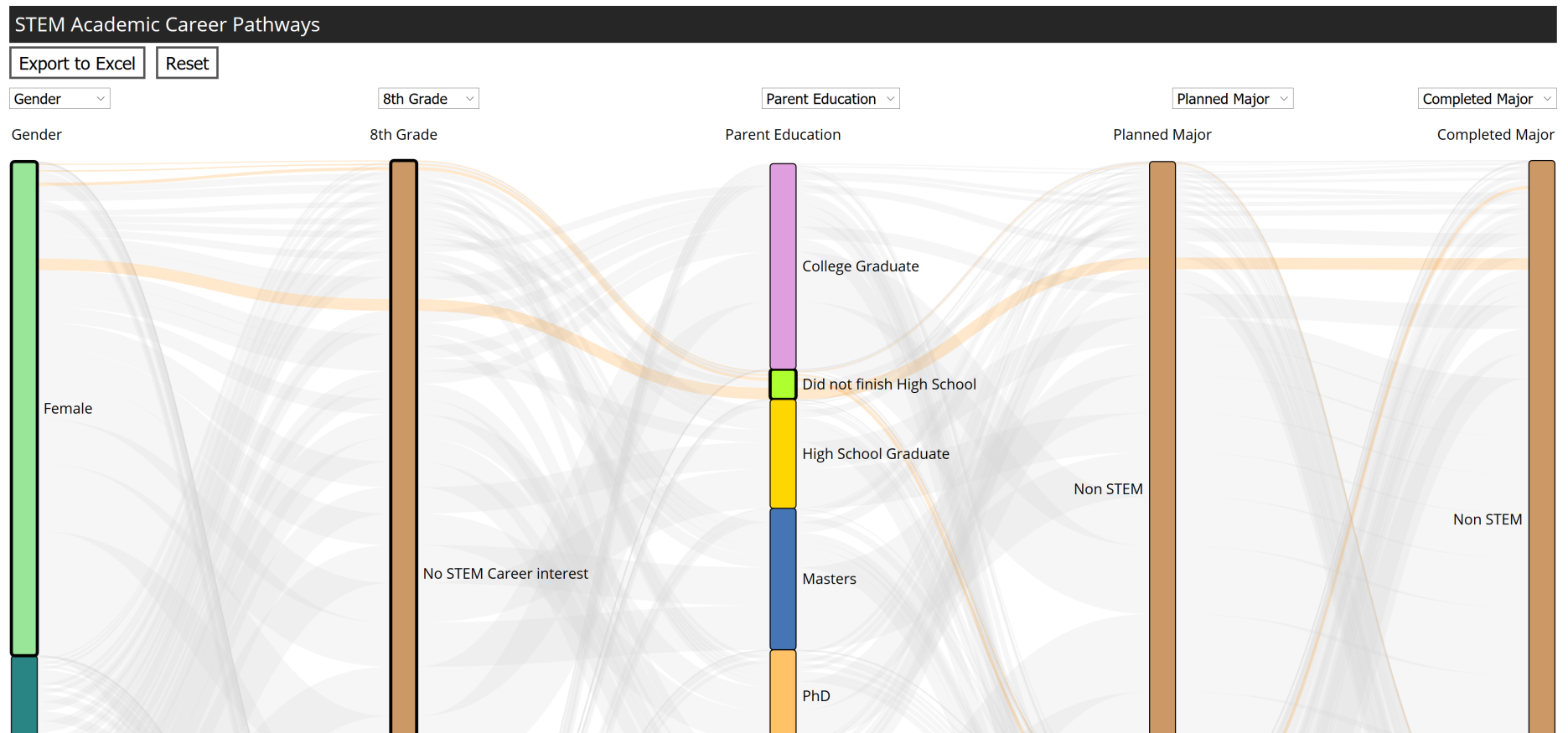


Description

The heat map visualization is a representation of student engagement (magenta to blue color scale) and performance (red to green color scale) throughout a course. The visualization has two levels. The top level provides an overview of engagement and performance for groups of students, while the bottom level provides a detailed break out of student engagement statistics for individuals with an identified group.

Custom interactive visualizations of 2015 IVMOOC student engagement and performance data, explore functionality online at <http://goo.gl/TYixCn>

Student Flows – STEM Academic Career Pathways



Measuring and Visualizing STEM Pathways. NSF NCSE-1538763 Award (Adam Maltese, Katy Börner) Aug. 15, 2015 - Jan. 2017.

Interactive web site: <http://demo.cns.iu.edu/client/stem>

Fall2015

Spring 2016

Spring 2016

Fall2016

Spring 2017

Statistics



Comp. Science



Info & Lib. Science



Informatics

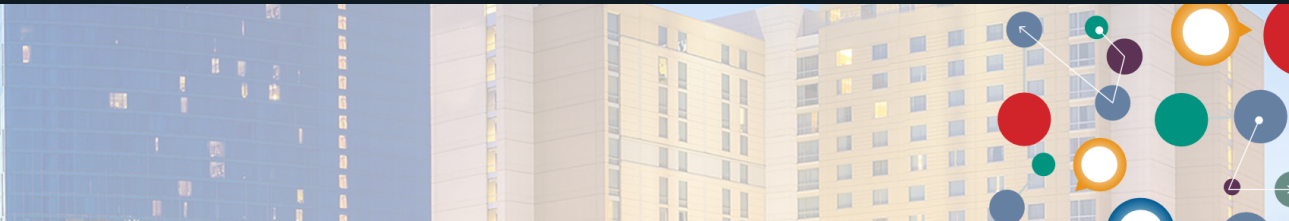


Data Visualization Literacy: Outlook



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📍 BLOOMINGTON, IN

📅 NOVEMBER 10 - 11, 2017

Program

Friday, November 10

Cyberinfrastructure Building

Innovation Center

7:45 AM Shuttles leave hotel for campus

8:00 AM Continental Breakfast and Registration

9:00 AM Welcome

9:30 AM Keynote

10:30 AM Coffee Break

11:00 AM **S1:** Cybersecurity (3 speakers)

S6: Funders and Funding

IEEE EnCON Conference will take place at CIB, IUB on Nov 10-11, 2017.

One sessions is devoted to “Engineering Education.”



SCWS 2017

Connecting the World
for a Sustainable Future

15th.Nov.-17th.Nov.2017

ACCESS / INQUIRY

EN JP

ABOUT

PROGRAMME

REGISTRATION

MARKETPLACE

SPONSORSHIP

PRACTICAL INFORMATION



Science Centre World Summit 2017 IN TOKYO

National Museum of Emerging Science and Innovation (Miraikan)

CSWS Session: Visualizing STEAM Data in Support of Smart Decision Making
November 15-17, 2017, Tokyo, Japan.



PROGRAMS

Awards

Koshland Science Museum

Cultural Programs

Sackler Colloquia

» About Sackler Colloquia

» Upcoming Colloquia

» Completed Colloquia

» Video Gallery

» Connect with Sackler Colloquia

» Give to Sackler Colloquia

Kavli Frontiers of Science

Distinctive Voices



Upcoming Colloquia

Unless otherwise indicated, most Sackler colloquia are held at the Arnold and Mabel Beckman Center, in Irvine, California.

Reproducibility of Research: Issues and Proposed Remedies

March 8-10, 2017; Washington, D.C.

Organized by David B. Allison, Richard Shiffrin and Victoria Stodden

Registration now open

Science of Science Communication III

November 15-16, 2017; Washington, D.C.

Organized by Karen Cook, Baruch Fischhoff, Alan I. Leshner and Dietram A. Scheufele

Registration will open May 2017

Modelling and Visualizing Science and Technology Developments

December 4-5, 2017; Irvine, CA

Organized by Katy Börner, William Rouse and H. Eugene Stanley

Registration will open August 2017

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

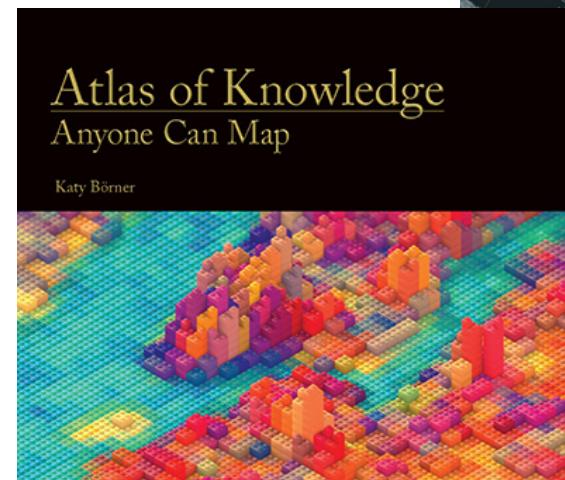
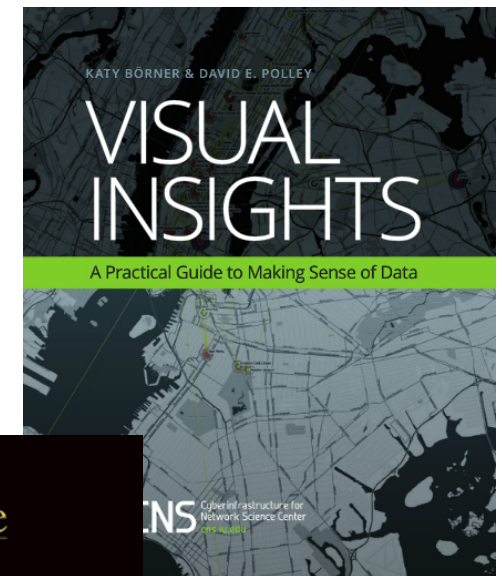
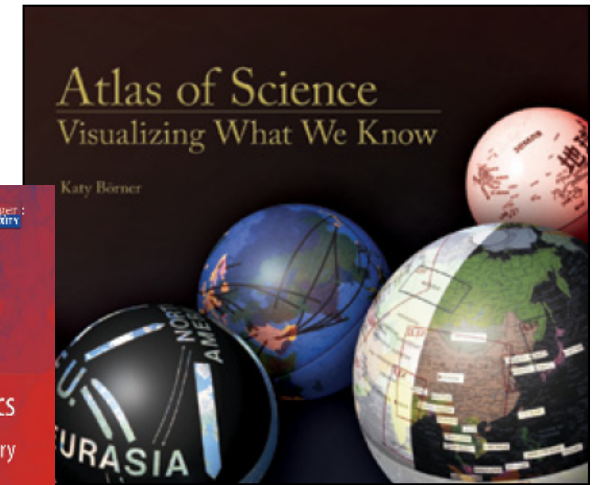
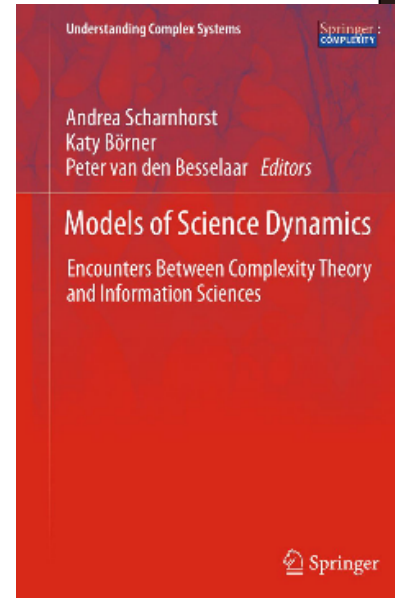
Börner, Katy (2010) **Atlas of Science: Visualizing What We Know**. The MIT Press. <http://scimaps.org/atlas>

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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We work closely with clients to provide custom-made data, visualization, and software solutions

Research
Open Data and Open Code for Big Science of Science Studies

Latest News
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 PIUG 2013 Northeast Conference
10.13 Katy Börner presents Mapping Science Exhibit at WSSF
10.15 Ted Polley & Google Team present IVMOOC at EDUCAUSE
10.22 Katy Börner presents at the SciELO 15 Years Conference

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

Outreach
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Videos
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