Visual (Learning) Analytics

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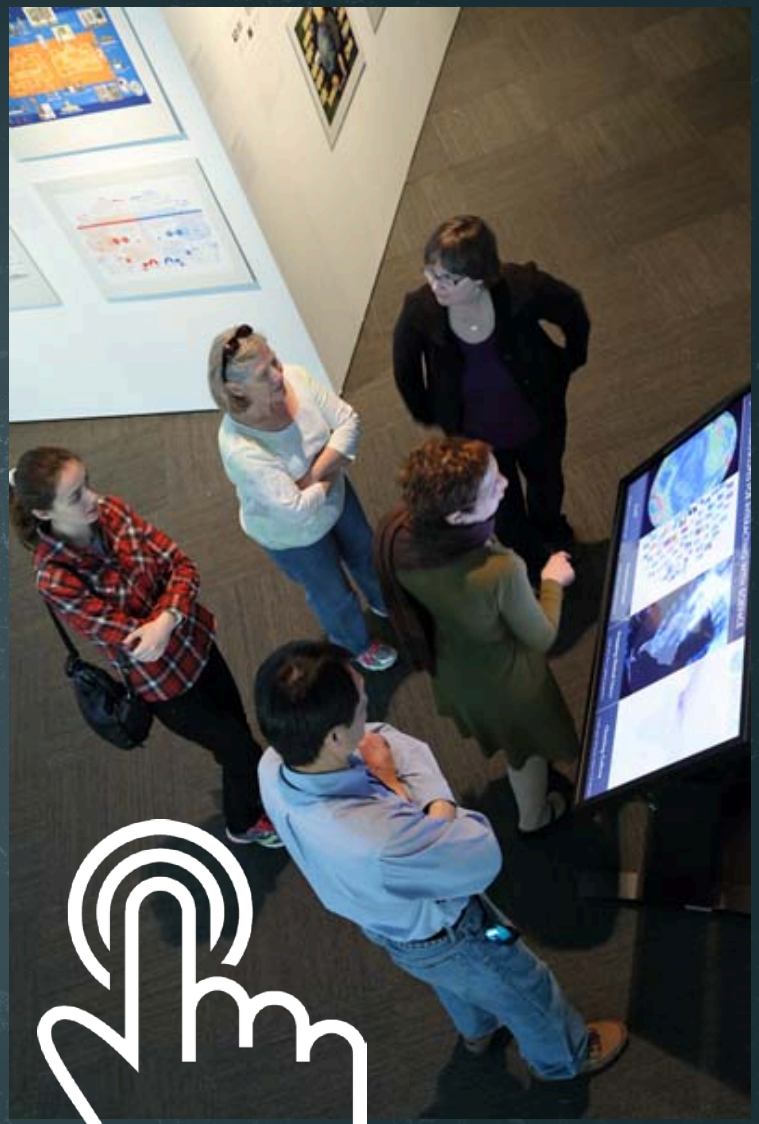
Meeting with ***Carol Rogers,*** *Deputy Director and CIO of the Indiana Business Research Center,* ***Mark Lawrance,*** *Senior Vice President, Foundation and Operations,* ***Darshan Shah,*** *Chief Data Officer*

August 17, 2017

Maps & Macroscopes

Data Visualization Literacy
IndyBigData > Opioid Vis Competition
IEEE EnCon

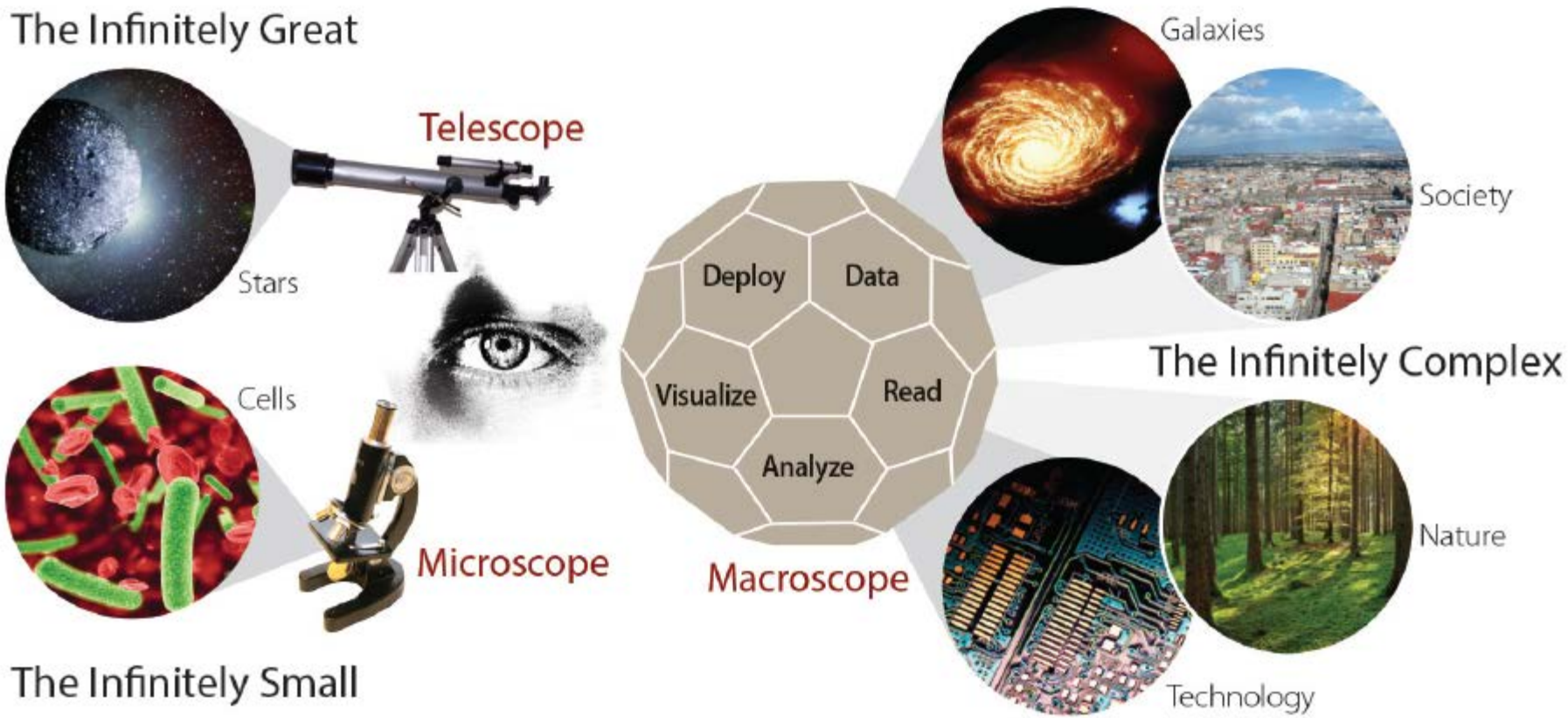


MAPS
vs.
MACROSCOPES

Iteration XI (2015): Macroscopes for Interacting with Science

http://scimaps.org/iteration/11

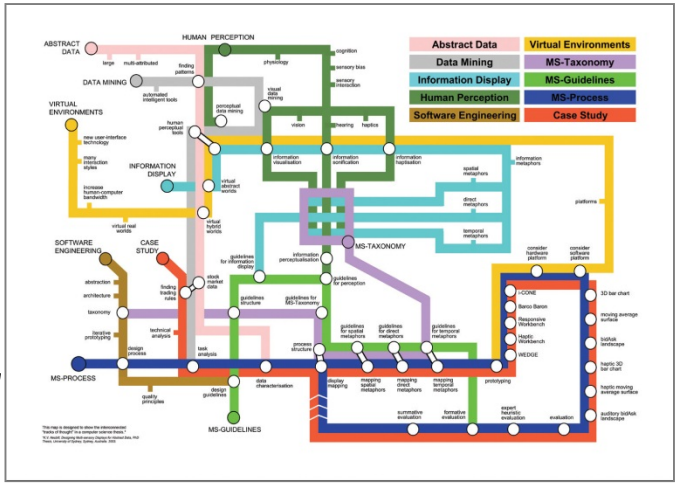
Microscopes, Telescopes, Macroscopes Plug-and-Play Macroscopes



Different Question Types

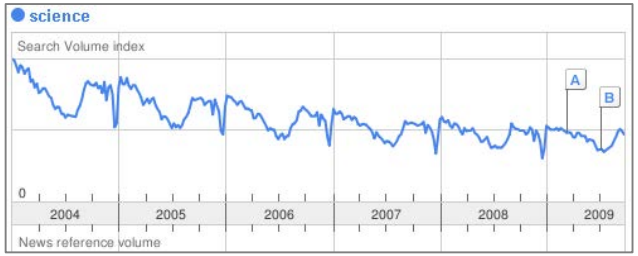
Terabytes of data

Descriptive & Predictive Models



Find your way

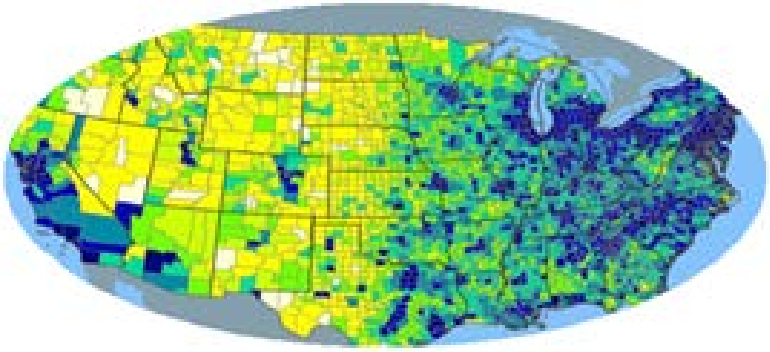
Find collaborators, friends



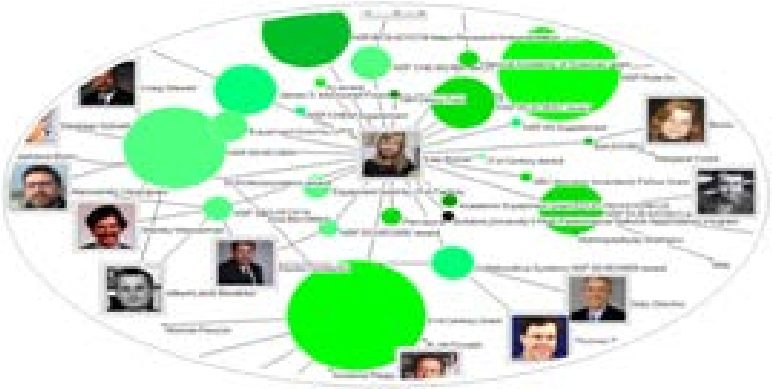
Identify trends

Different Levels of Abstraction/Analysis

Macro/Global
Population Level



Meso/Local
Group Level



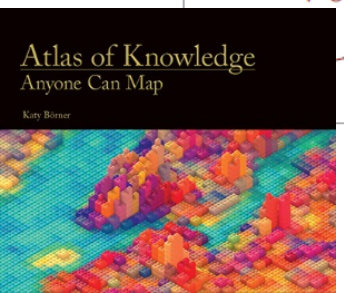
Micro
Individual Level
OR
Below skin

Tasks

LEVELS

TYPES

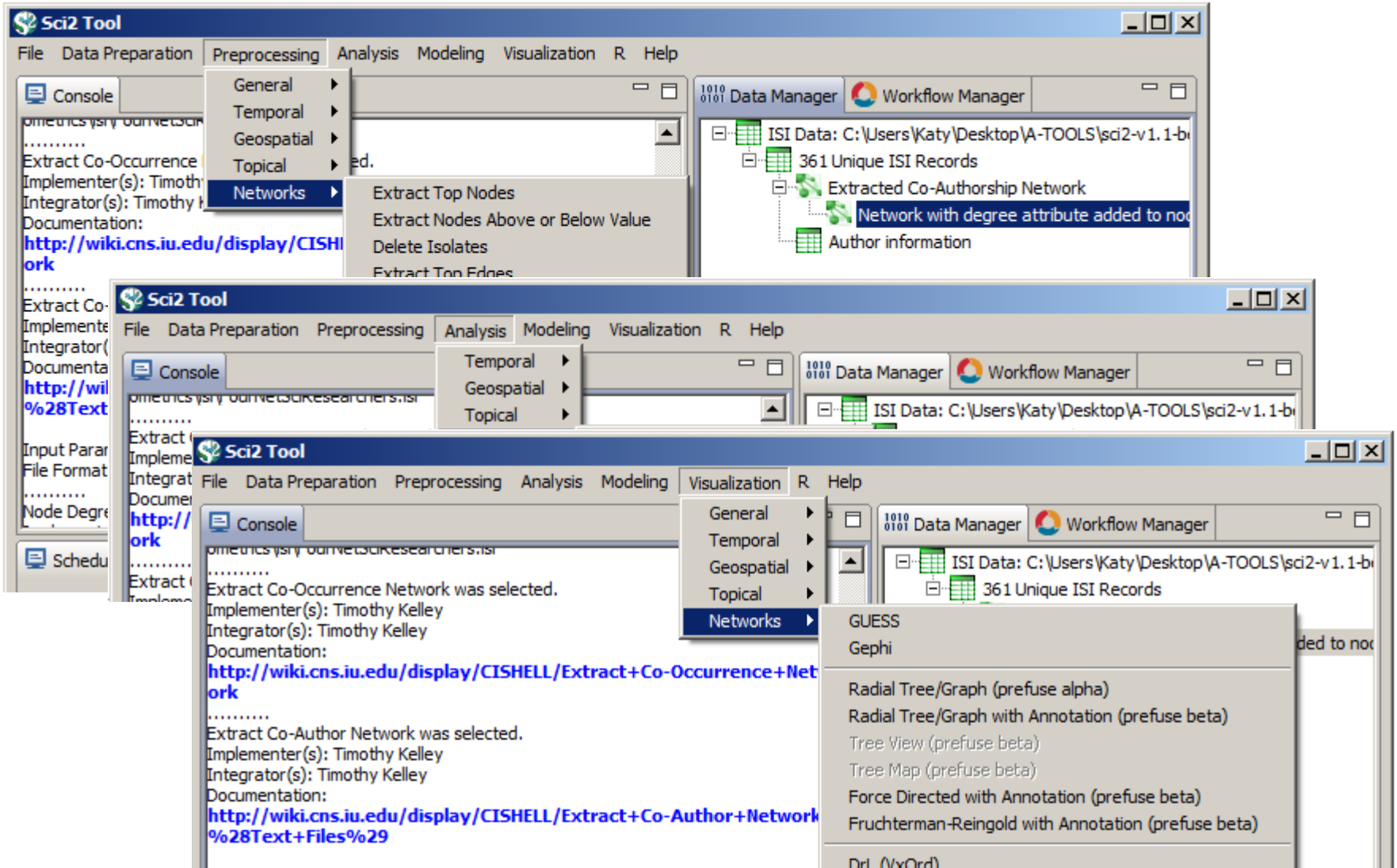
TYPES	MICRO: Individual Level about 1–1,000 records page 6	MESO: Local Level about 1,001–100,000 records page 8	MACRO: Global Level more than 100,000 records page 10
Statistical Analysis page 44	Knowledge Cartography page 135	Productivity of Russian life sciences research teams page 105	Number of scientists 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 *Atlas of Science: Anyone Can Map*, page 5

Sci2 Tool Interface Components Implement Vis Framework

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

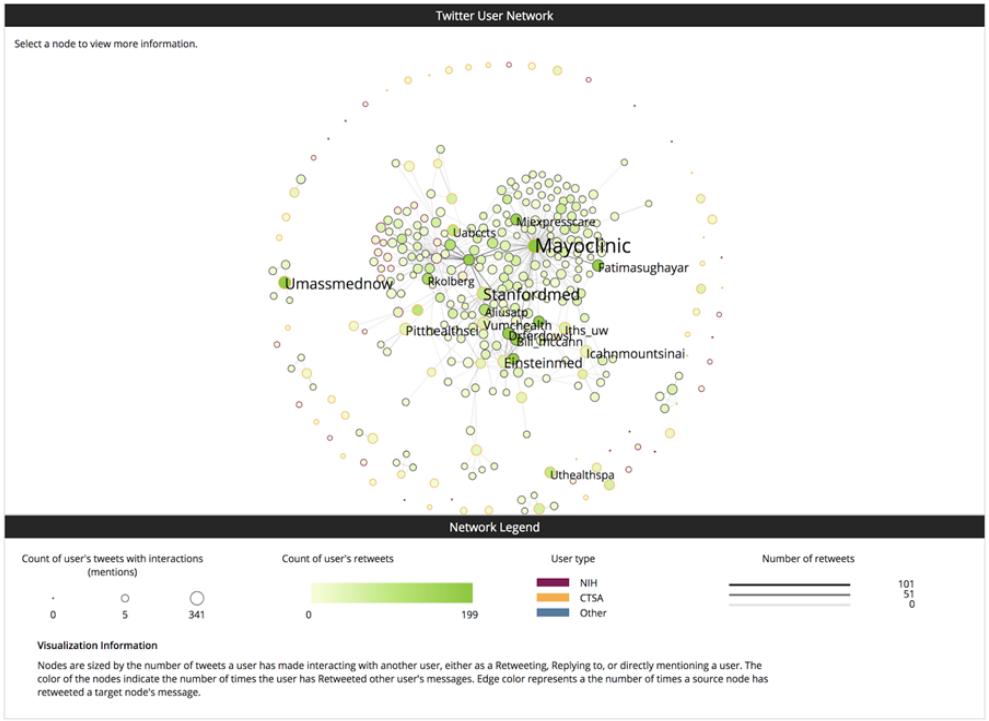


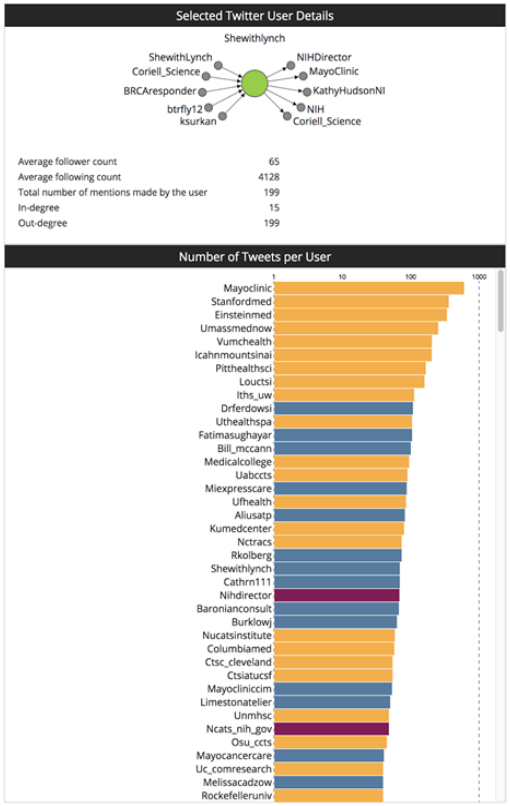
Interactive Visualizations using CNS WebVis Framework

Visualization: Twitter Network

Project: IAI

demo.cns.iu.edu/client/iai/twitter.html

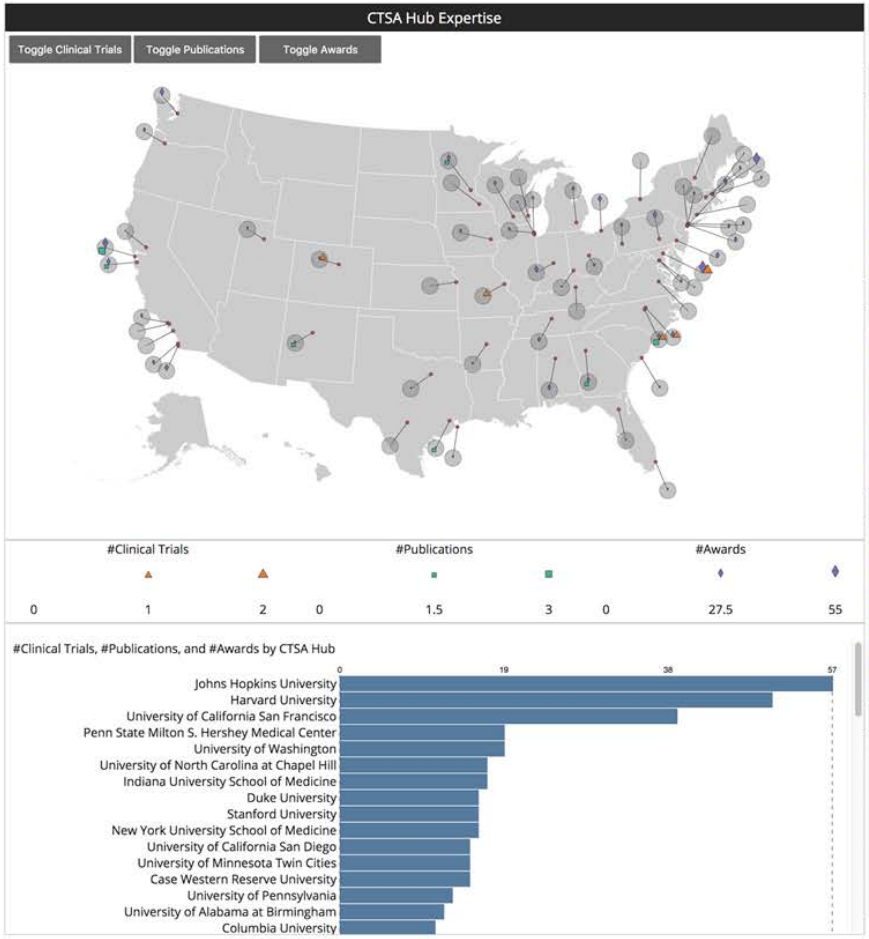




Visualization: IAI Expertise Visualization

Project: IAI

demo.cns.iu.edu/client/iai/expertise.html?set=malaria



Filter 'malaria' Results

Filter (Disabled) | Filter...

Clinical Trials

Title	Institution	Status	Start Date
Initial Study of Malaria Vaccine Pfs25-EPA/Alhy	Johns Hopkins University	Completed	2011
Novel mHealth Platform to Ensure Quality of C	Duke University	Not yet recruiting	2015
Phase I Study of the Safety and Immunogenicit	Johns Hopkins University	Completed	2009
Impact of Host Iron Status and Iron Supplemer	University of North Carolina at Chapel Hill	Recruiting	2009
Effect of Sprinkles With and w/o Fe on Zn Absc	University of Colorado Denver	Active, not recruiting	2011
Metabolic Effects of Hydroxychloroquine	Washington University	Recruiting	2012

Publications

Title	Institution	Journal Name	Publication Year
Epidemiologic features impacting the pr	University of Texas Health Science Cent	Pediatr. Infect. Dis. J.	2010
Ascaris co-infection does not alter mala	Emory University	Malar. J.	2013
IFNγ→/IL-10 co-producing cells domin	University of California San Francisco	PLoS Pathog.	2014
Placental malaria among HIV-infected a	University of California San Francisco	Malar. J.	2009
Decline in childhood iron deficiency afte	University of Minnesota Twin Cities	Am. J. Clin. Nutr.	2014
Randomized, placebo-controlled trial to	Stanford University	Hum Vaccin Immunother	2013
Does this patient have malaria?	University of North Carolina at Chapel H	JAMA	2010
Suppressed circulating bicyclo-PGE2 lev	University of New Mexico Health Scienc	Biochem. Biophys. Res. Commun.	2013

Awards

Title	Institution	Amount	Start Date
Determinants of Plasmodium liver invasion	Johns Hopkins University	$1,457,626	2009
Urban malaria mapping: a new methodology to a	Harvard University	$169,875	2011
Wolbachia as an Agent for Population Replaceme	Johns Hopkins University	$427,677	2007
Molecular Mimics of Protein Tertiary Folding from	University of Pittsburgh	$1,080,934	2013
Genetic Association Mapping of Malaria Resistanc	University of Minnesota Twin Cities	$2,769,718	2007
Beta-catenin signaling in endothelial cells during	New York University School of Medicine	$989,522	2015
Mentoring Translational Research in HIV	University of California San Diego	$916,215	2012
Malaria Transmission and the Impact of Control E	Johns Hopkins University	$13,171,654	2010

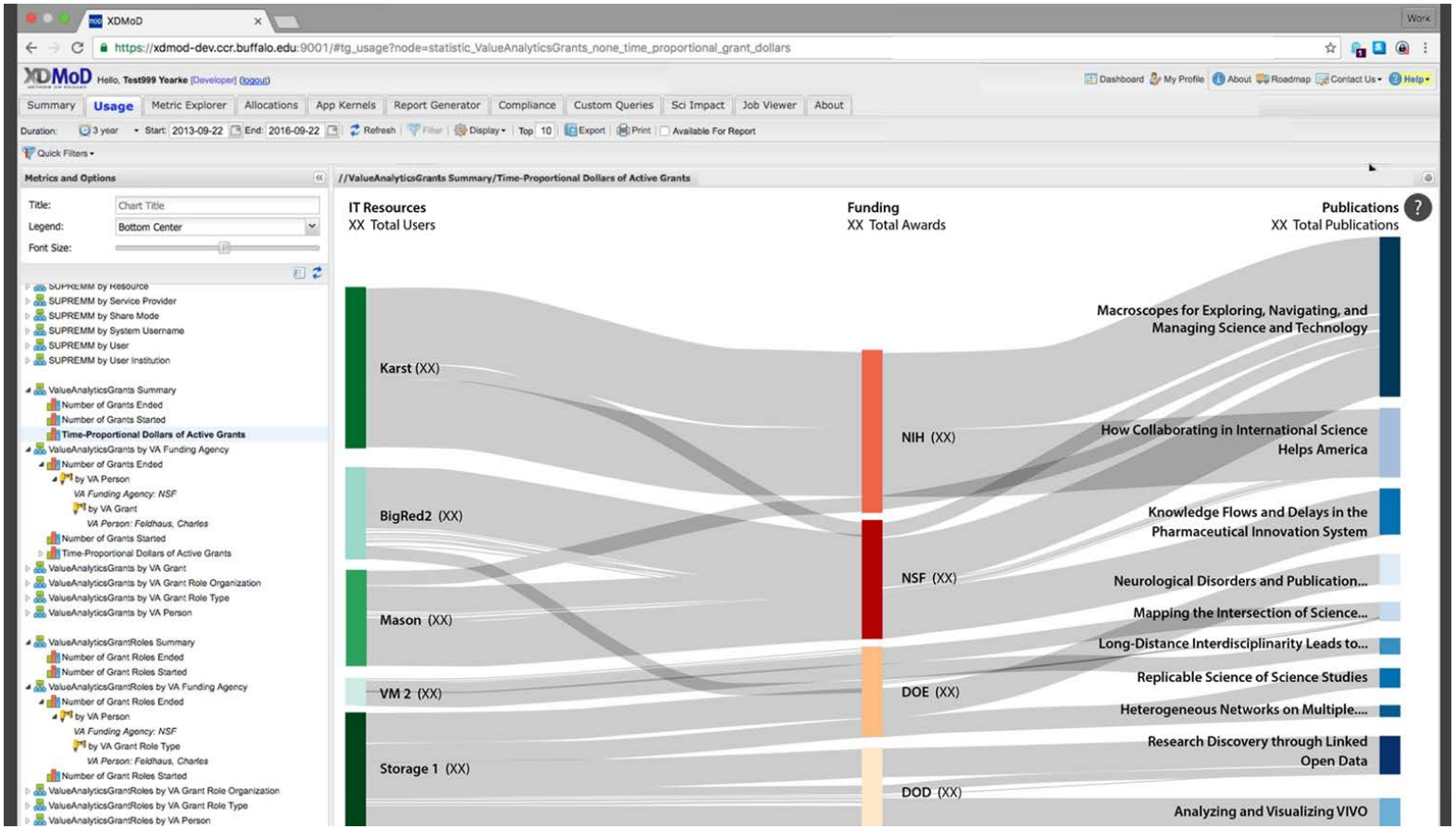
Personnel Expertise

Name	Institution	#Public.	#Awards
Gloria E Oramasionwu	University Of Texas Health Science Center At Houstor	1	0
Francisca A Abanyie	Emory University	1	0
Prasanna Jagannathan	University Of California San Francisco	2	0
Patrick M Newman	University Of California San Francisco	1	0
Anne E P Frosch	University Of Minnesota Twin Cities	1	0
C Buddy Creech	Stanford University	1	0
Steve M Taylor	University Of North Carolina At Chapel Hill	1	0
Samuel B Anyona	University Of New Mexico Health Sciences Center	1	0

This visualization is based on publication datasets retrieved from the Scholarly Database at IU, and is used to identify relevant experts, publications, clinical trials, and awards that match a search term.

Visualization: Sankey Diagram

Project: XDMoD

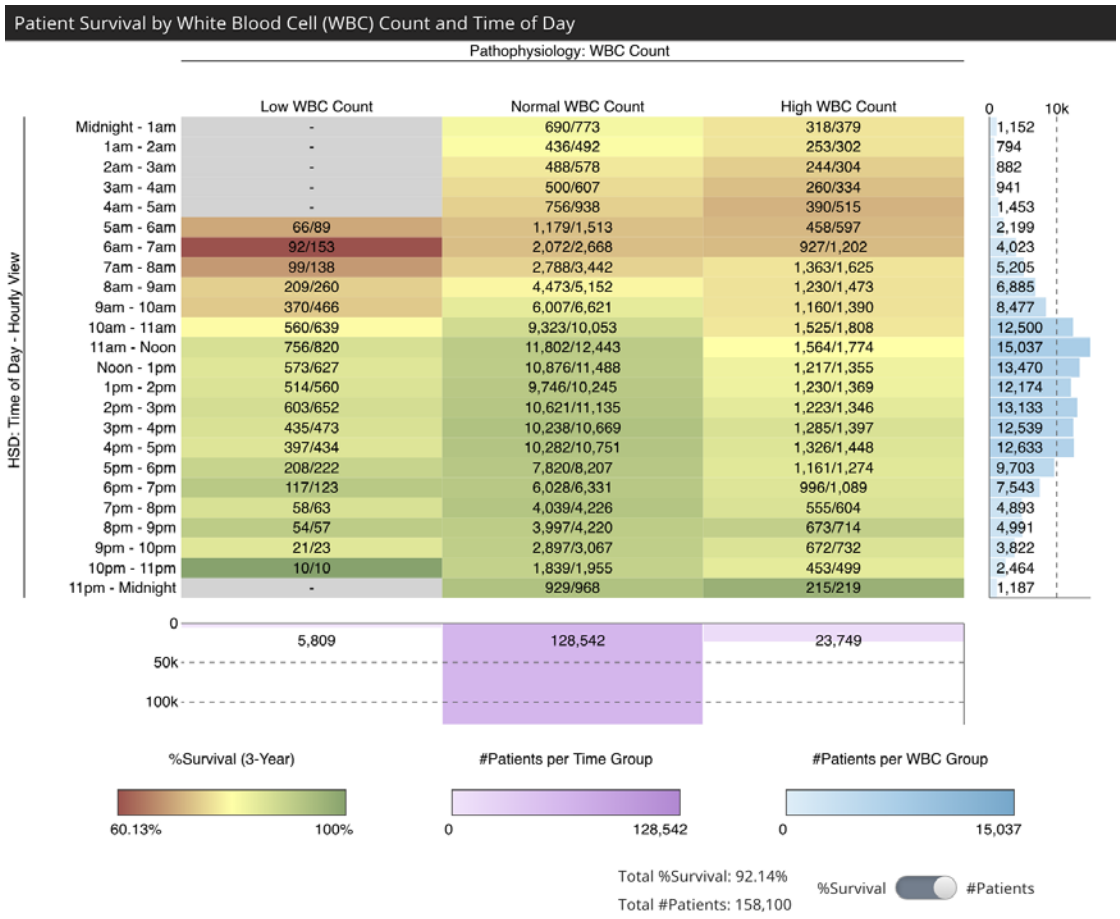


This Sankey diagram displays a multivariate analysis of the relationship between IT resources, funding agencies, and publications. The width of each line represents grant dollars awarded to researchers. The configuration model allows for easy metric switching.

Visualization: Heatmap

Project: HSD

demo.cns.iu.edu/client/hsd/static/heatmap_hour.html



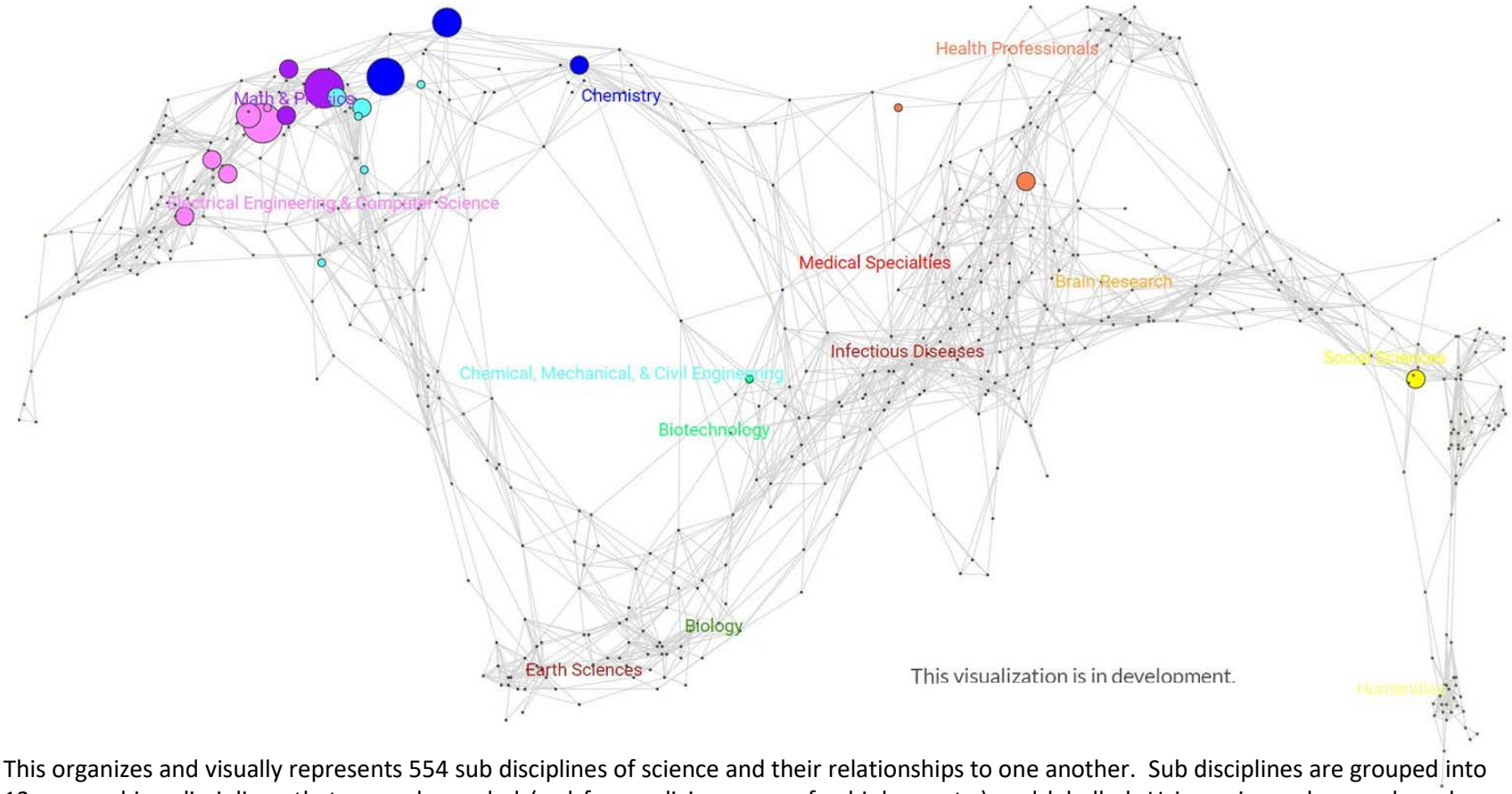
This visualization shows how white blood cell (WBC) laboratory tests correlate with three-year survival rates. The HSD dimension of the data (rows) is the time of the day of the test; and three-year survival rate (numbers and colors in the boxes) is an outcome variable. **Aggregation level for the HSD time of day are shown— 24 hourly blocks on the right.**. The lowest survival rates are for patients with a low WBC value in the morning (specifically at 6am).

In this project, we created data visualizations to explain HSD to users and to help them incorporate it into in their research.

Visualization: UCSD Map of Science

Project: ERC

nanohub.org/citations/curate

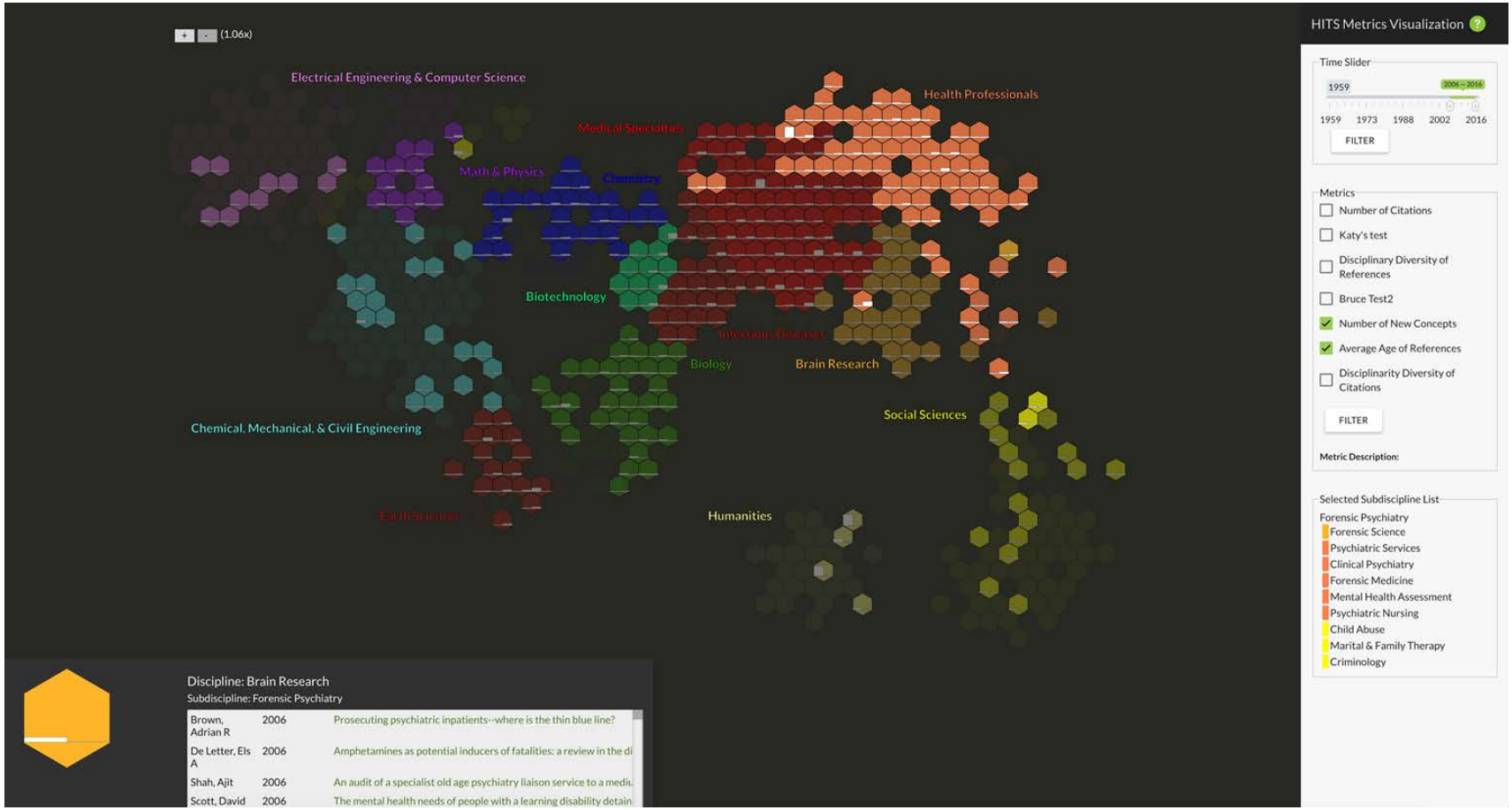


This organizes and visually represents 554 sub disciplines of science and their relationships to one another. Sub disciplines are grouped into 13 overarching disciplines that are color coded (red for medicine, green for biology, etc.) and labelled. Using a journal name based or keyword based mapping process, data overlays can be computed. For example, expertise profiles for an individual or an institution are generated by reading a bibtex or EndNote file with relevant publications, identifying unique journal names, and overlaying geometric symbols such as circles atop the sub discipline(s) that are associated with each journal. This Map of science can be used to explore, understand, and communicate the expertise profiles of an institute or nation.

Visualization: Hex Map of Science

Project: ECON

demo.cns.iu.edu/client/econ-hexmap



Hex-style rendering of the UCSD map of science allows for easier investigation of metric bars within each hexagon node. This Interactive map allows the user to hover over a discipline label to highlight all its subdisciplines, and also hover over a subdiscipline to see all subdisciplines it is connected to.

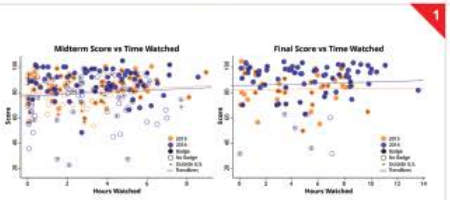
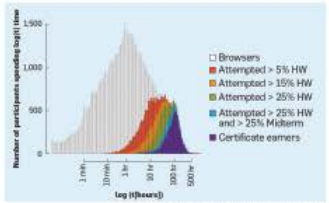
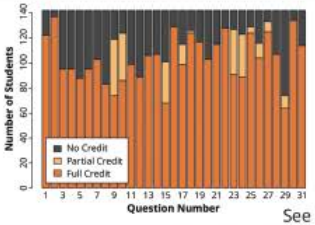
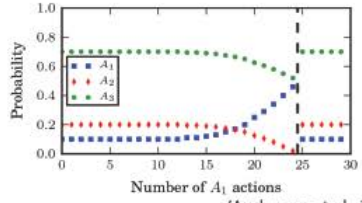
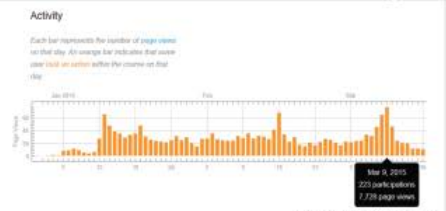
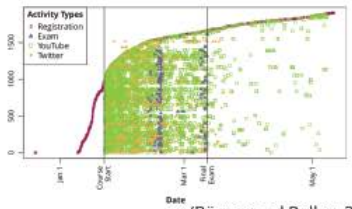
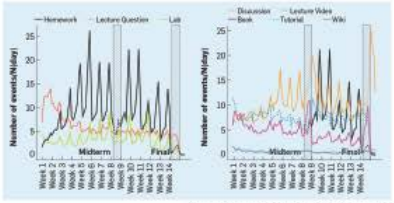
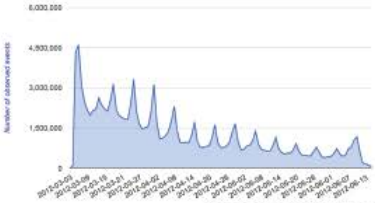
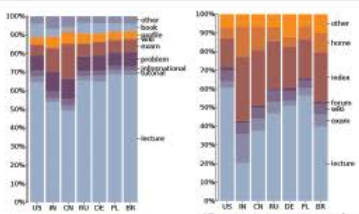
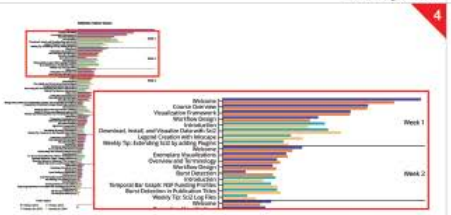
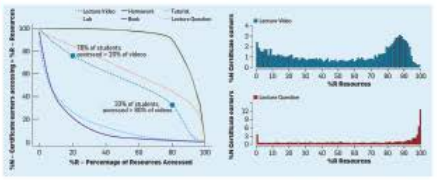
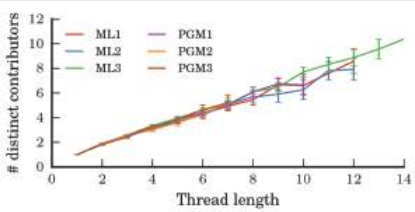
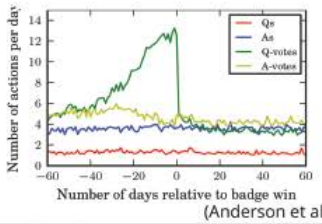
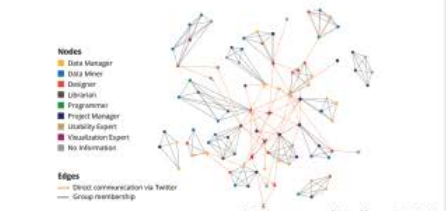
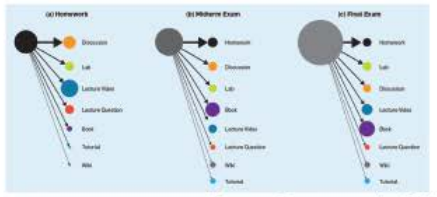
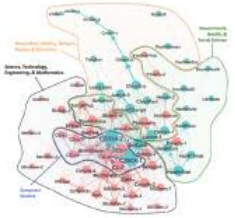
Register for free: http://ivmooc.cns.iu.edu. Class restarts Jan 9, 2018.

Learning Analytics

IVMOOC
IU DS
EDS@IU
Boeing

Analysis and Visualization Types vs. User Need Types

IVMOOC

	A Student	B Teacher	C Researcher	D Developer
1 Statistics	 See Figure 1	 (Seaton, Bergner, et al., 2014)	 See Figure 3	 (Anderson et al., 2013)
2 Temporal	 (Instructure, 2014)	 (Börner and Polley, 2014)	 (Seaton, Bergner, et al., 2014)	 (Dernoncourt et al., 2013)
3 Geospatial	See Figure 2	(Dernoncourt et al., 2013)	 (Dernoncourt et al., 2013)	("GlobalNOC," 2007)
4 Topical	 See Figure 4	 (Seaton, Bergner, et al., 2014)	 (Anderson et al., 2014)	 (Anderson et al., 2013)
5 Network	 (Börner and Polley, 2014)	 (Seaton, Bergner, et al., 2014)	 (Ho et al.)	(Ginda, 2014)

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)*.

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

Inactive Active Very Active

0% 25% 50% 75% 100%

Score

F D C B A

0% 60% 70% 80% 100%

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 Client Projects: All Interactions

Nodes

Previous experience with information visualization

- No response
- Very Low
- Low
- Medium
- High
- Instructors

Edges

- Direct communication via Twitter
- Group membership

Educational Data Science:
Precision Learning, Teaching, and Leadership

IU Emerging Area of Research Proposal

"We will develop, validate, and optimize models that explain and help predict the impact of different interventions on student success at IU and in life."

SCHOOL OF INFORMATICS AND COMPUTING
INDIANA UNIVERSITY
Bloomington

INDIANA UNIVERSITY
KELLEY SCHOOL OF BUSINESS
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INDIANA UNIVERSITY
DEPARTMENT OF PSYCHOLOGICAL AND BRAIN SCIENCES
College of Arts and Sciences
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College of Arts and Sciences
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DEPARTMENT OF ANTHROPOLOGY
INDIANA UNIVERSITY
College of Arts and Sciences
Bloomington

Bloomington Assessment and Research

INDIANA UNIVERSITY
OFFICE OF THE VICE PROVOST FOR UNDERGRADUATE EDUCATION
Bloomington

The Team

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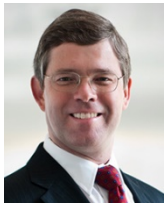
- **Robert Goldstone**, Chancellor's Prof, Psychological & Brain Sciences, COAS
- **Dennis Groth**, Vice Provost for Undergraduate Education
- **Daniel Hickey**, Prof, Learning Sciences Program, SoE
- **Michael Kaganovich**, Prof of Economics, Economics, COAS
- **George Rehrey**, PI Consultant with IU's CITL; Director of SOTL
- **Anastasia Morrone**, Prof of Educational Psychology, IUPUI School of Education; Associate Vice President for Learning Technologies, OVPIT; Dean of IT at IUPUI
- **Jennifer Meta Robinson**, Prof of Practice, Anthropology, COAS
- **Linda Shepard**, Senior Assistant Vice-Provost for Undergraduate Education; Director of Bloomington Assessment & Research
- **Timothy F. Slaper**, Indiana Business Research Center, IUB



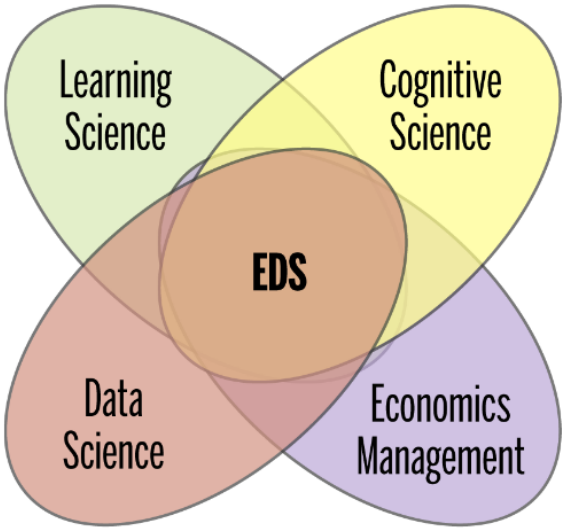
Big Questions

- What would college students, faculty, and other stakeholders do differently if they had easy, first-hand access to the data already created by college life in the information age?
- What wisdom about learning and life could students actualize from pathways visualized through documents, data, code, expertise, laboratory outcomes, class performance, and grades?
- What leverage points for learning could faculty discern and operationalize?
- What interventions should faculty/units/institutions implement for positive gains?

Research Cores

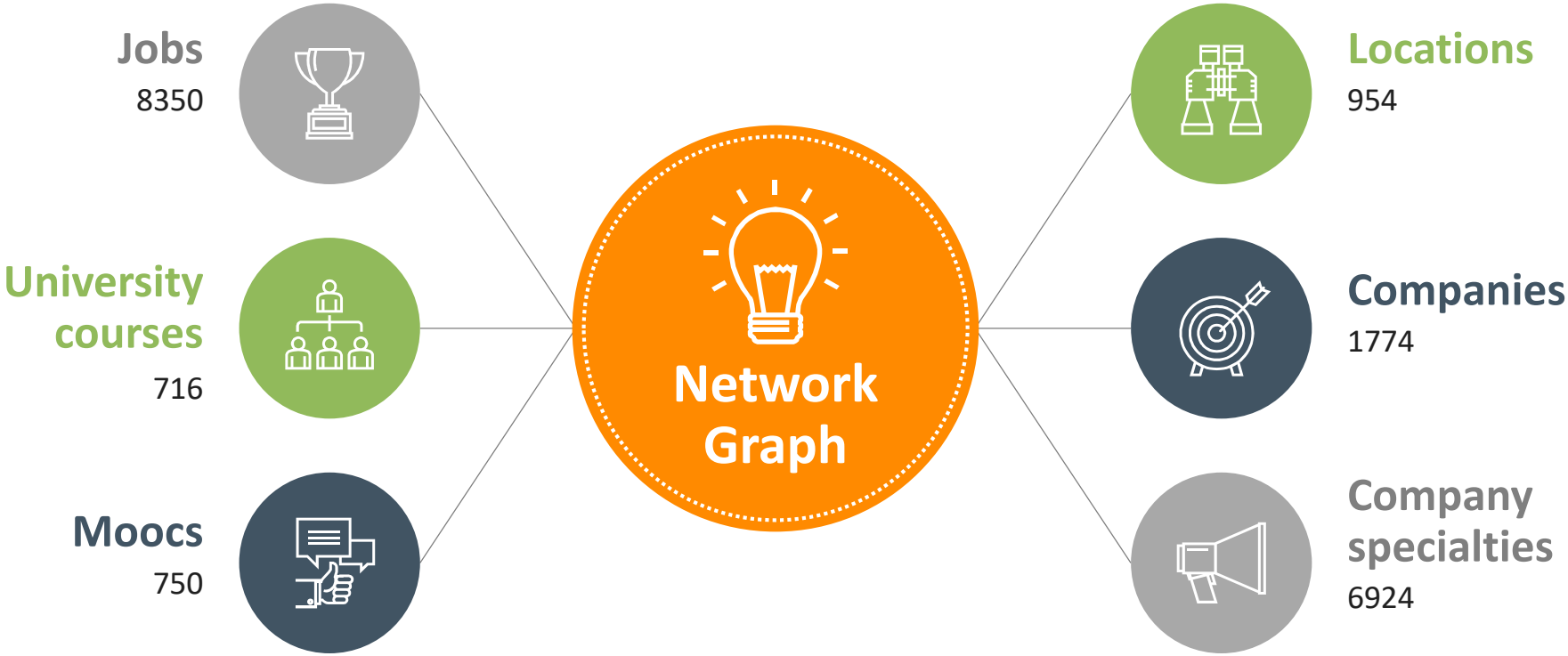
The team will perform cutting-edge, interdisciplinary research in **Educational Data Science (EDS)** at the intersection of four research areas:

- ***Cognitive Science > Classroom Experiments*** investigates the cognitive and social variables, patterns, and leverage points in learning and teaching.
- ***Learning Science > Student Support*** investigates the impact of curricular interventions on student success at IU and in life.
- ***Decision Science: Economics of Higher Education*** investigates the economic value of education across scales—from micro to macro. ***Management/Student Choice Research*** investigates the impact of incentives and educational product offerings on short-term and long-term decision making.
- ***Data Science > Learning Analytics*** performs research on data mining, modelling, and visualization techniques that increase "data (visualization) literacy" and data-driven decision making.



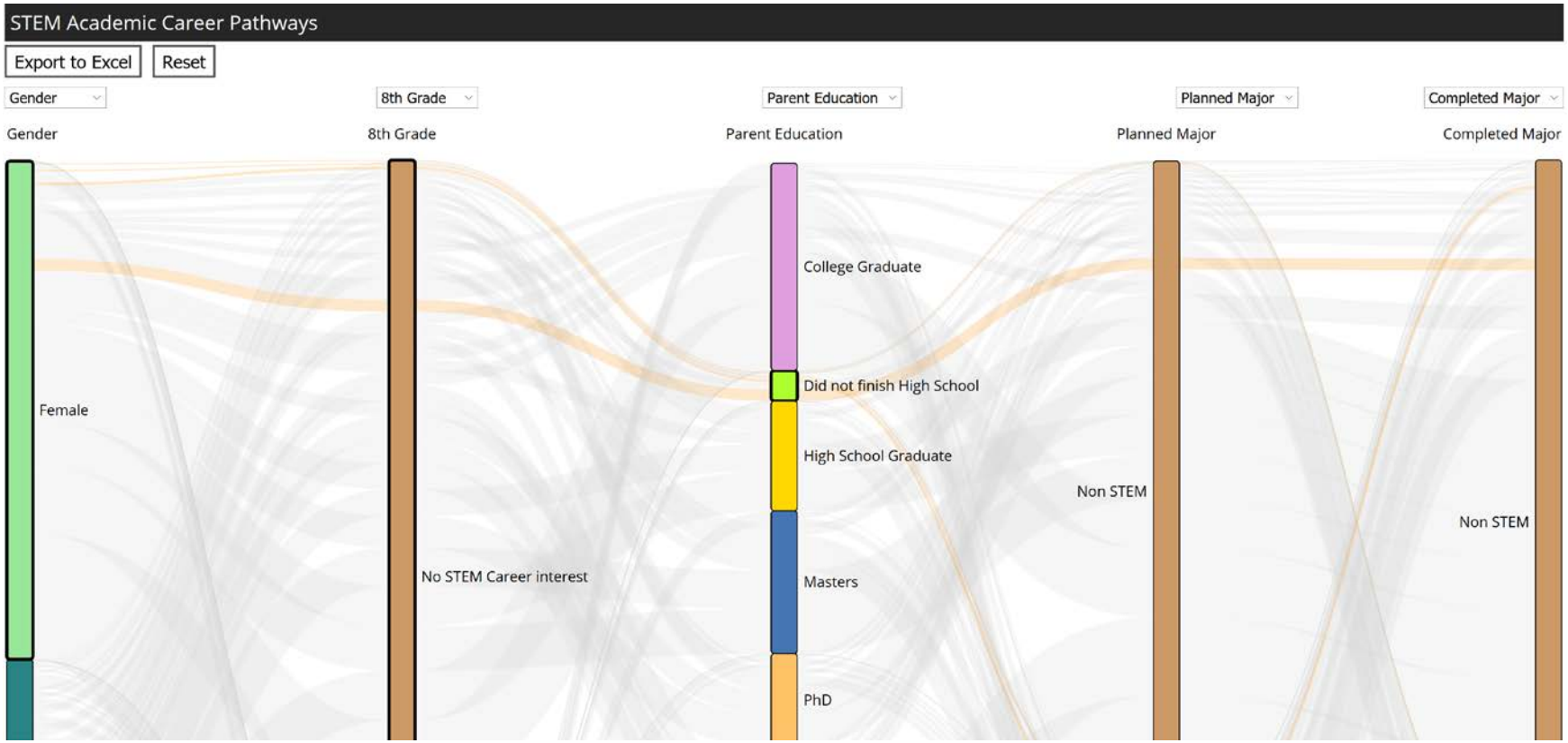
Enter a Job, Get Course Recommendations

The system represents information on jobs, courses, companies, etc. via a heterogeneous knowledge graph with 395,030 nodes and 993,526 edges.
Students pick a dream job; then text and graph-based algorithms recommend optimized education opportunities, i.e., courses that maximize time, money, and/or learning.



Li, Nan, Naren Suri, Zhen Gao, Tian Xia, Katy Börner, and Xiaozhong Liu. 2017. "Enter a Job, Get Course Recommendations". *iConference 2017, Wuhan, China*.

Student Flows – STEM Academic Career Pathways

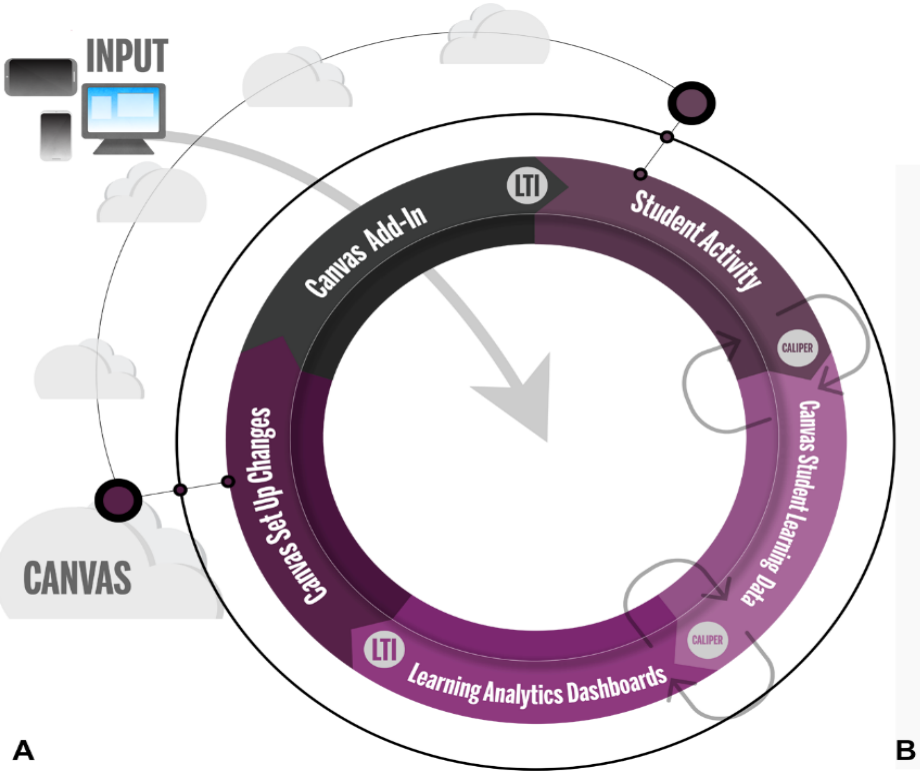


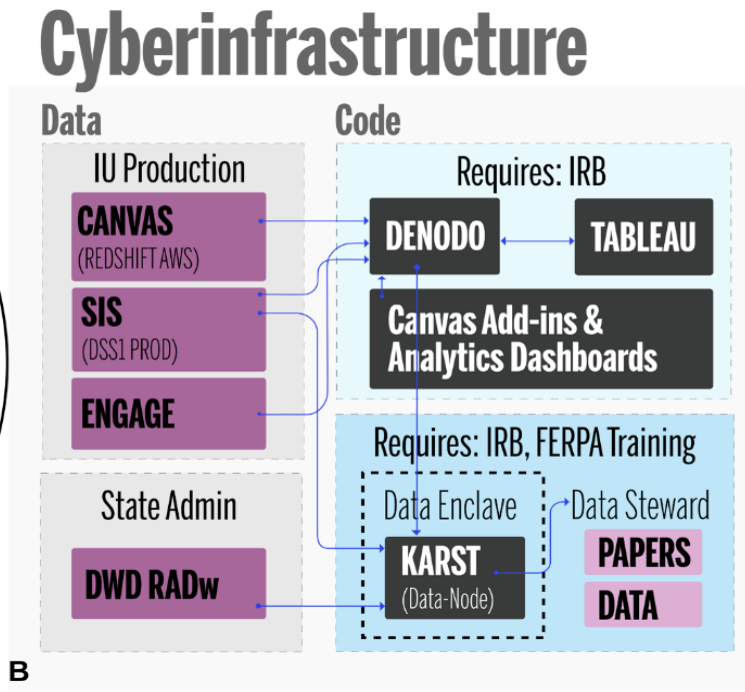
Measuring and Visualizing STEM Pathways. NSF NCSE-1538763 Award, 2015-2017.

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

Cyberinfrastructure Core

- Implements novel means to provision sensitive data via secure data enclaves and federated Denodo virtualized databases.
- Develops novel functionality for existing learning management systems (LMS) such as Canvas using LTI and Caliper.
- Uses/extends Tableau to serve actionable dashboards for IU leadership.





Establishing EDS and Ensuring IU Leadership

Capitalizing on existing IU strengths:

- Student Learning Analytics (SLA) Fellows Program
- Scholarship of Teaching and Learning Program
- Learning Technologies, UITS
- Learning Science Research, PBS, COAS
- Cognitive Science Program, IUB
- Learning Sciences Program, School of Education
- Bloomington Assessment and Research (BAR) office
- Indiana Business Research Center, http://ibrc.indiana.edu
- Decision Support Initiative, http://dsi.iu.edu

Proactive collaborations with other institutions:

- Unizin—11-institution digital learning consortium, http://unizin.org
- Bay View Alliance—8-institution Student Learning Analytics (SLA) initiative

INDIANA UNIVERSITY

CENTER FOR INNOVATIVE TEACHING AND LEARNING

Office of the Vice Provost for Undergraduate Education / University Information Technology Services Bloomington

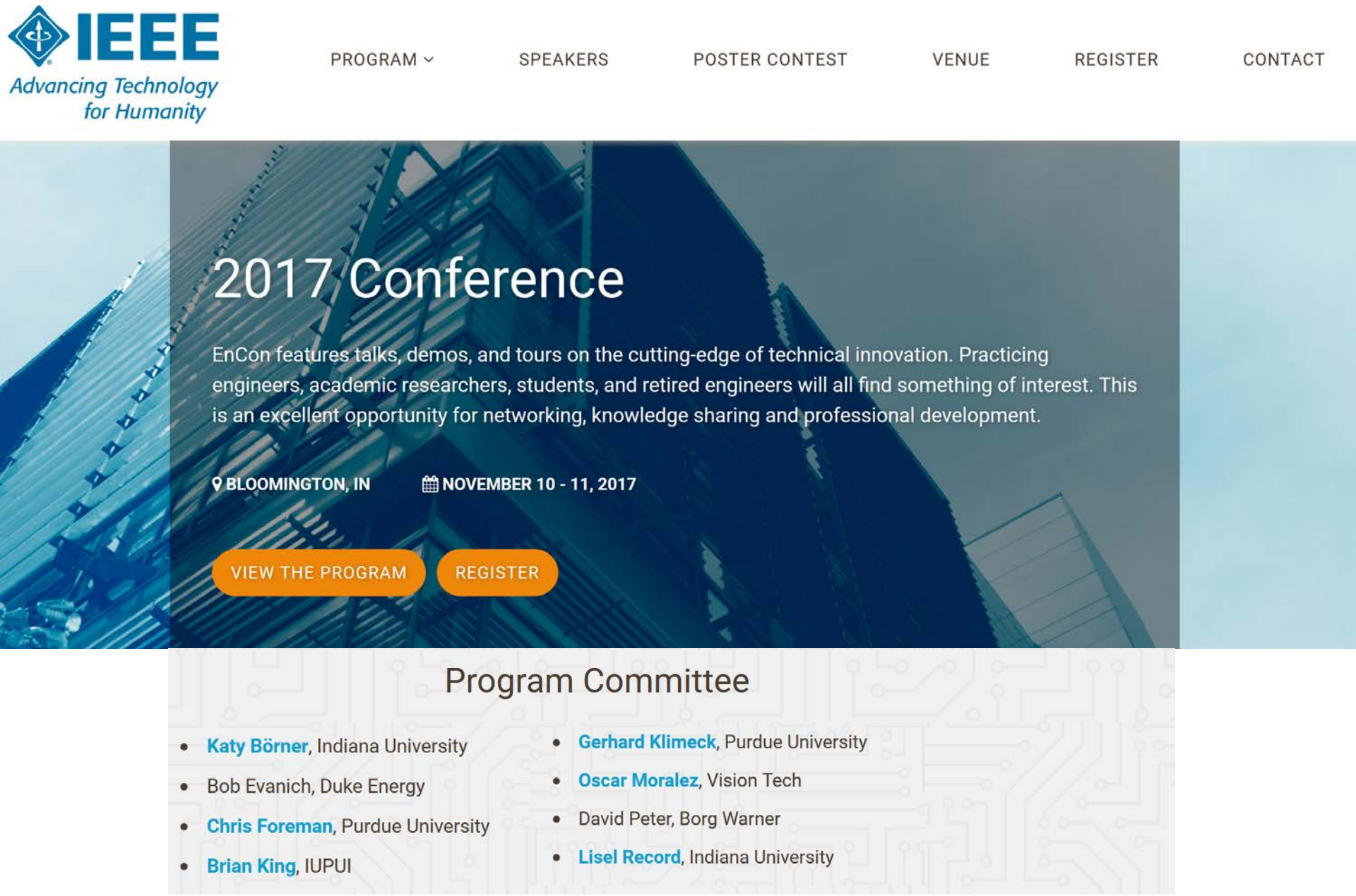
IBRC

Bloomington Assessment and Research

Unizin

Outlook

Data Visualization Literacy
IndyBigData > Opioid Vis Competition
IEEE EnCon



http://www.cis-ieee.org/encon2017

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

Arthur M. Sackler COLLOQUIA

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

http://www.nasonline.org/programs/sackler-colloquia/upcoming-colloquia

CSWS Session: Visualizing STEAM Data in Support of Smart Decision Making
November 15-17, 2017, Tokyo, Japan.
https://scws2017.org/programme/detailedprogramme/2

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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

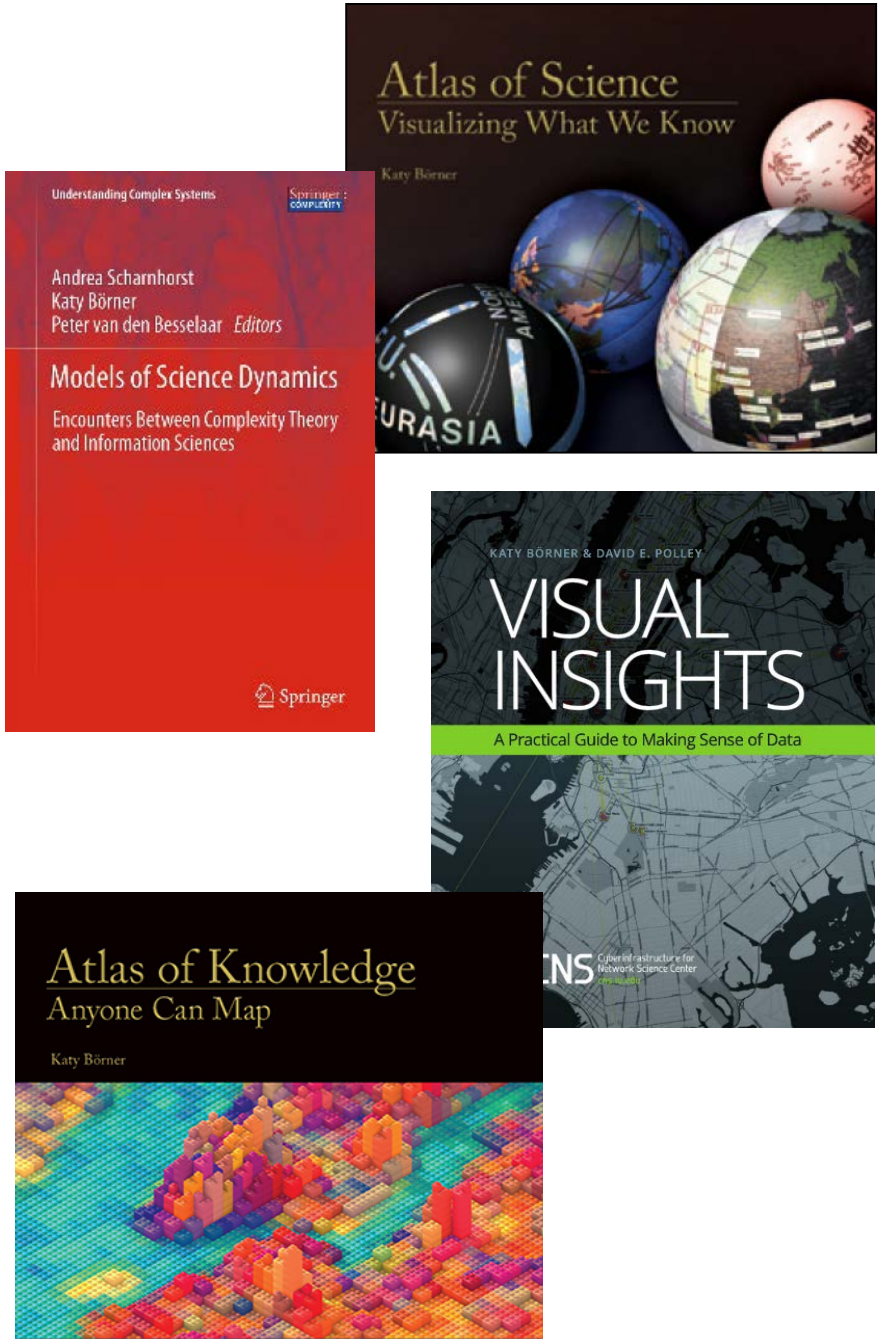
Shiffrin, Richard M. and Börner, Katy (Eds.) (2004). **Mapping Knowledge Domains**. *Proceedings of the National Academy of Sciences of the United States of America*, 101(Suppl_1). http://www.pnas.org/content/vol101/suppl_1

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 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



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

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Mapping Science Exhibit Facebook: http://www.facebook.com/mappingscience

Macroscope Demo