Science in a Digital Age:
The potential of a new science+lib partnership to enhance the impact of STEM scholarship

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Geology & Geophysics, Texas A&M University

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A Scientist in the Library

Alexis de Tocqueville

(French: 29 July 1805 – 16 April 1859) was a French political thinker and historian best known for his works *Democracy in America* (appearing in two volumes: 1835 and 1840)

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Digital scholarship: current status

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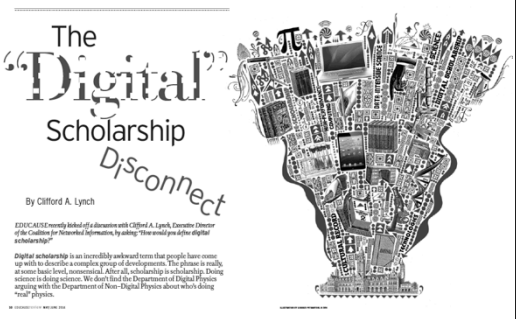
Digital Scholarship

- High performance computing
- Visualization
- Networking
- Curation and preservation of data and publications


The "Digital" Scholarship Disconnect

By Clifford A. Lynch

EDUCAUSE recently kicked off a discussion with Clifford A. Lynch, Executive Director of the Coalition for Networked Information, by asking: "How would you define digital scholarship?"

Digital scholarship is an incredibly awkward term that people have come up with to describe a complex group of developments. The phrase is really, at some basic level, nonsensical. After all, scholarship is scholarship. Doing science is doing science. We don't find the Department of Digital Physics arguing with the Department of Non–Digital Physics about who's doing "real" physics.

Lynch, C. (2014) Educause Review 22(9): 46s-58s

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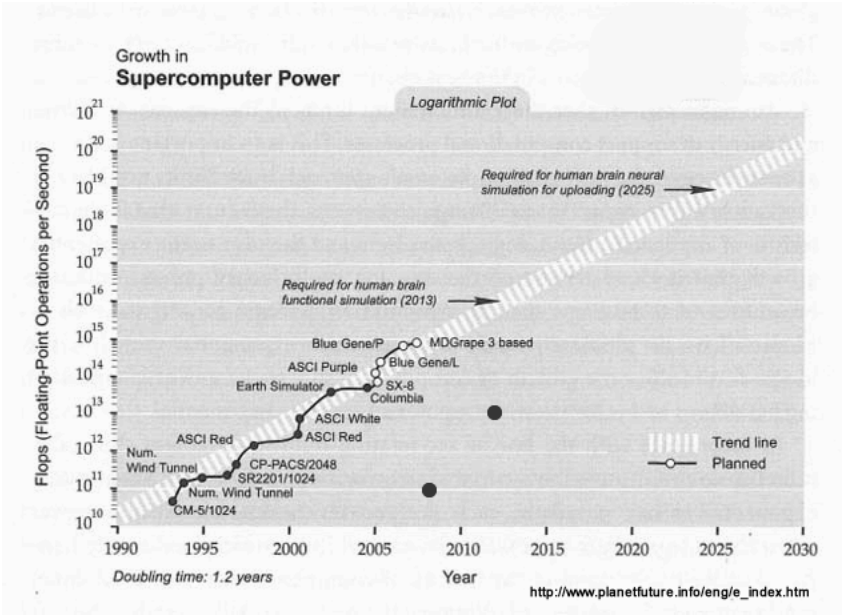

Digital scholarship: new avenues of scholarship

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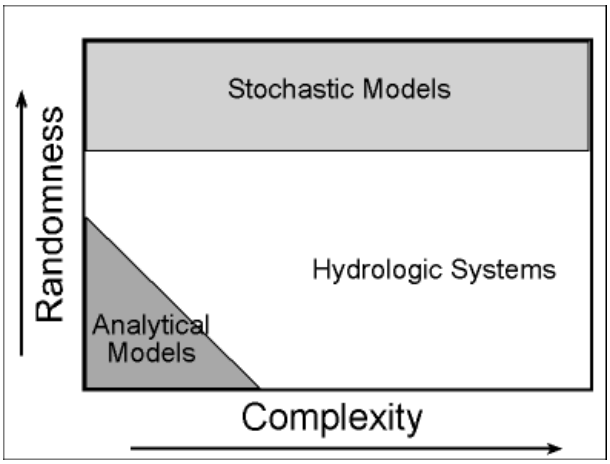
Emerging Scholarship

Earth and Environmental Systems

Natural systems tend to be in realms where randomness and complexity make deterministic modeling difficult.

Major inquiry methods

- Simulations
- Characterization of natural systems
- Experiments on model systems



Dooge, J. (1986) Water Resour. Res. 22(9):46s-58s

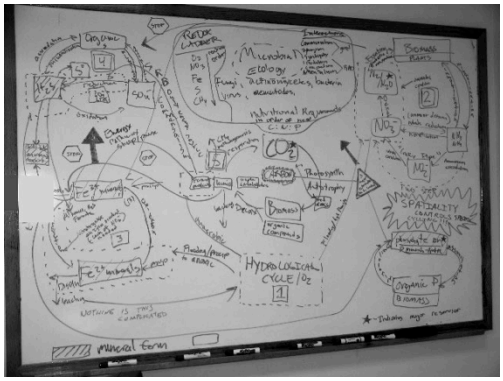
Emerging Scholarship

Complex Systems

A complex system is distinguished from a complicated system by behaviors or characteristics that emerge as a result of the interactions between elements of the systems, not through some external agent.

Complex Systems

- Soils
- Fluvial systems
- Ecosystems
- Earth quakes
- Living organisms
- Stock market and most other social organizations
- Classrooms



Concept Map of Biogeochemical Processes in a Wetland

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Nature of Complex Systems

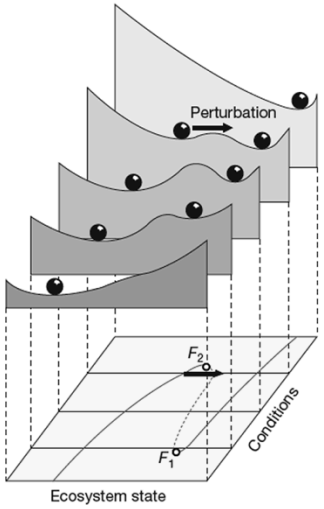
Complex systems consist of interacting parts with open boundaries

- Operate across a wide range of scales; hierarchical
- Usually exists far from equilibrium
- Nonlinear relationships with positive and negative feedbacks
- Exhibit irreversibility, hysteresis, or chaotic behavior
- Bifurcations to multiple states
- Self-organization and emergent properties
- Deterministic and stochastic components that are essential to system stability

The study of animal aggregations such as schools of fish is one of the more surprising areas in which complexity theory is proving useful. It is being applied to understand the evolutionary advantages and drawbacks of group behavior. ***Science*** *Vol 284 Apr 2 1999*

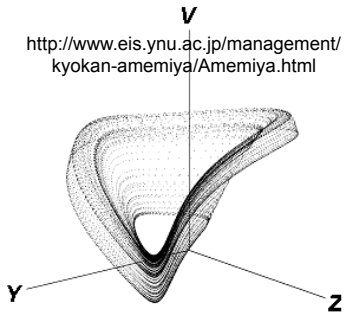
Stable States of Complex Systems

Resilience of multi-stable systems



Scheffer et al., 2001

Strange attractor



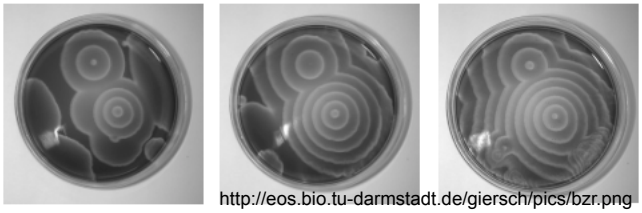
http://www.eis.ynu.ac.jp/management/kyokan-amemiya/Amemiya.html

An attractor is a set to which the system evolves after a long enough time.

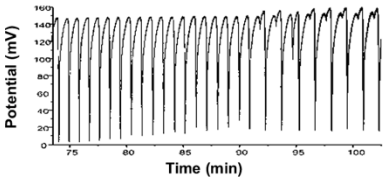
Geometrically, an attractor can be a point, a curve, a manifold, or a complicated set with fractal structures known as a strange attractor.

Pattern Formation in Belousov-Zhabotinsky (BZ) Reactors

BZ reactors are spatio-temporal chemical oscillators. Using specific proportions of chemicals, a series of competing and oscillating reaction steps develop.

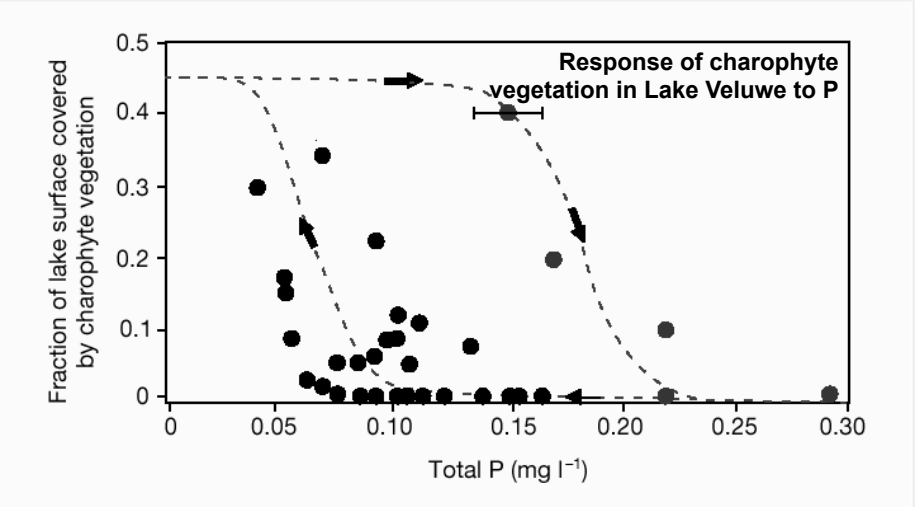


http://eos.bio.tu-darmstadt.de/giersch/pics/bzr.png



A single experimental record, by Pt electrode, of simple and complex behavior observed as transients on the way to final equilibrium in a closed vessel.

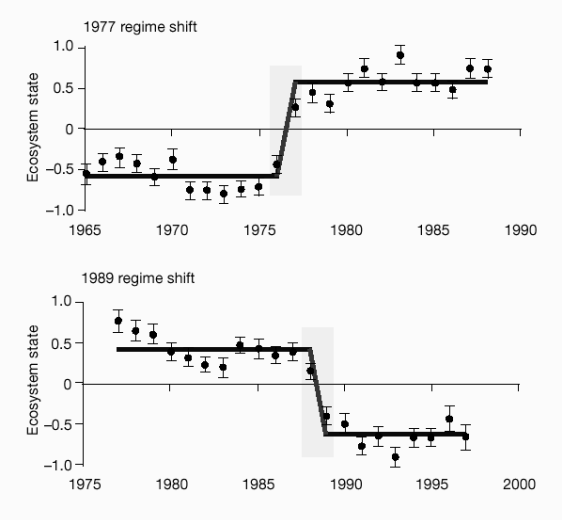
Ecological Hysteresis in a Shallow Lake



Scheffer et al., 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.

Ecosystem Bifurcations in the Pacific Ocean

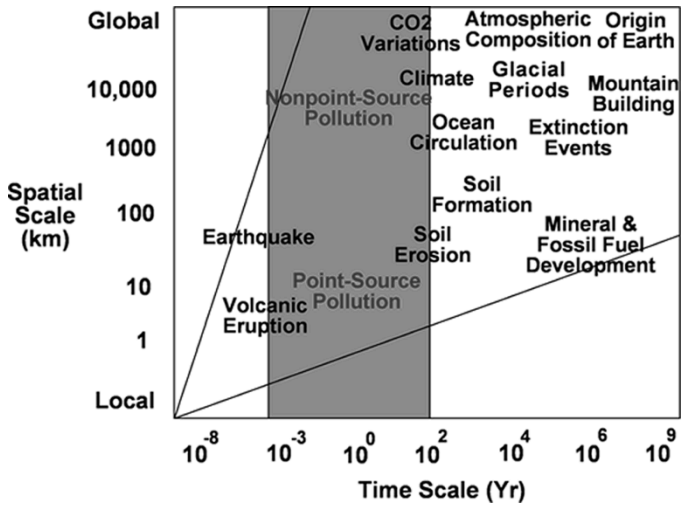
Compound indices of ecosystem state were developed from 31 climatic and 69 biological normalized time series



Scheffer et al., 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.

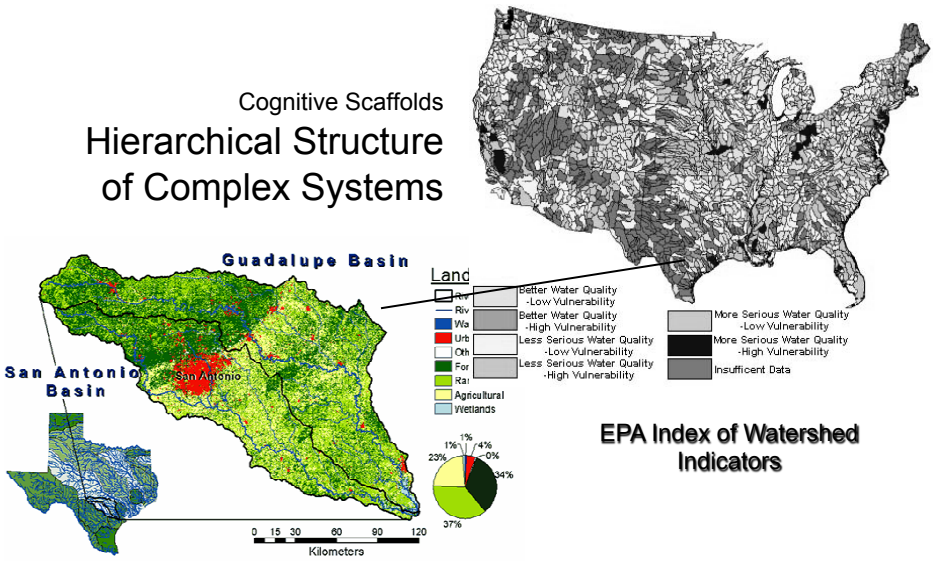
Cognitive Scaffolds

Spatial & Temporal Scales of Earth Systems



Cognitive Scaffolds

Hierarchical Structure of Complex Systems

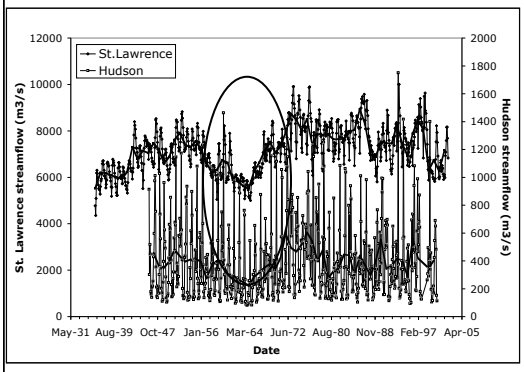


EPA Index of Watershed Indicators

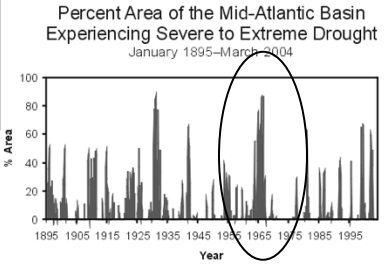
The Guadalupe and San Antonio - and major underlying aquifers - the Edwards and Carrizo-Wilcox are the focus of the proposed Texas Hydrologic Observatory (http://www.txh2o.org/)

Cognitive Scaffolds

Focus on Average Properties



Drought Temporal and Spatial Variability



Based on data provided by the National Climatic Data Center, NOAA

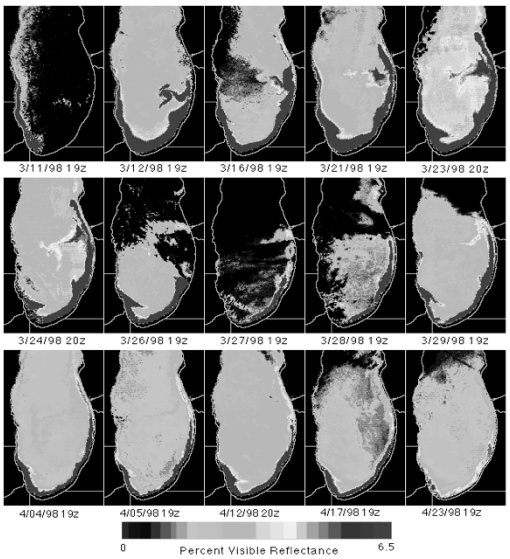
Northeast Atlantic Region

Cognitive Scaffolds

Turbulence as Chaotic Systems

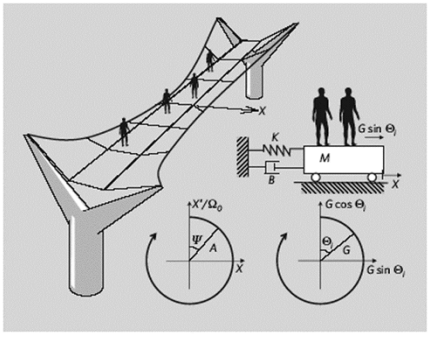
1998 Suspended Sediment Plumes on Lake Michigan

Keith W. Bedford, Philip Chu and David Welsh
Department of Civil and Environmental Engineering and Geodetic Science
The Ohio State University

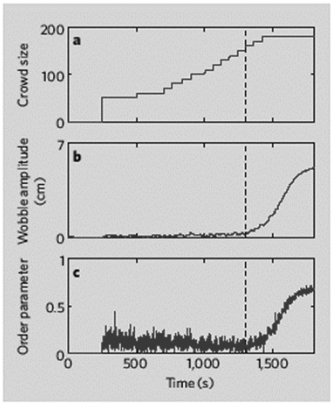


Development of Accurate Causal Models

Crowd synchrony on the Millennium Bridge



Swaying was first thought to be due to design. The resonant lateral mode of vibration of the bridge is represented by a mass-spring-damper system.



Wobbling of the bridge and crowd synchrony emerge together as dual aspects of a single instability mechanisms

Strogatz et al., 2005. Nature. 438(3):43

Digital scholarship: emerging needs

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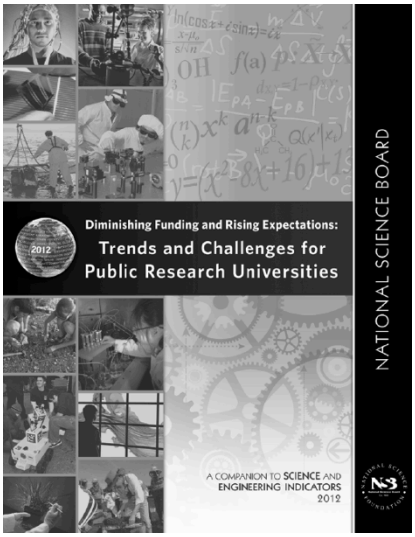
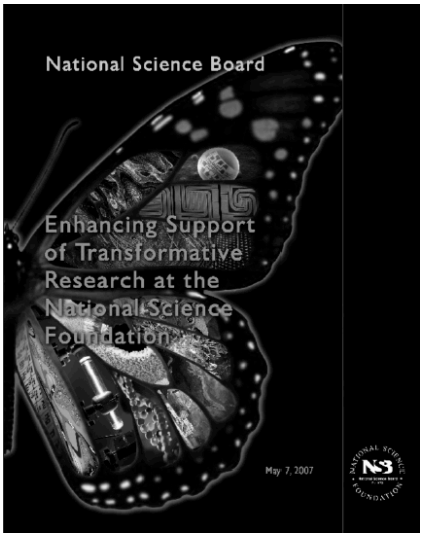
Public Universities & Transformative Science





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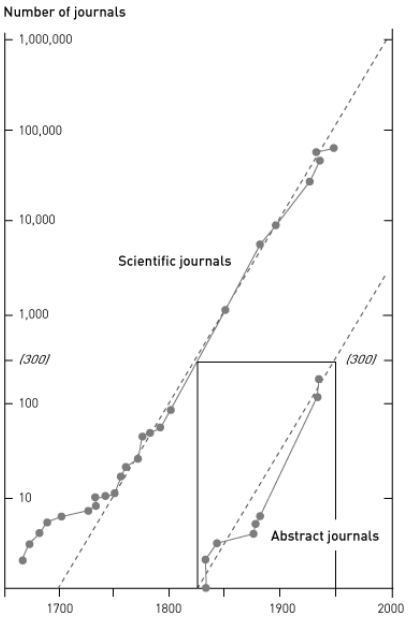

http://www.researchtrends.com/issue7-september-2008/journals-as-retention-mechanisms-of-scientific-growth/

Emerging Issues

Information Management

The number of journals founded (not surviving) as a function of date is an illustration of the exponential growth of the scientific journal literature since the first journals in 1665.

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Emerging Issues

Information Management

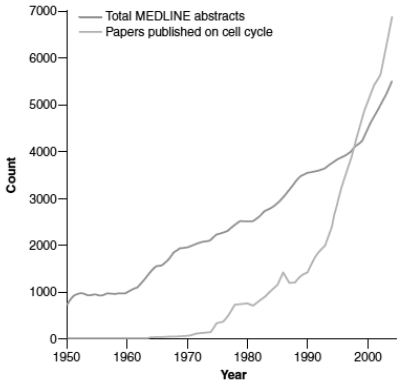


Fig. 1. Increase in number of papers published each year in biomedicine and in one specialized topic, the cell cycle. [Adapted with permission from MacMillan Publishers, *Nature* (5)| copyright 2006]

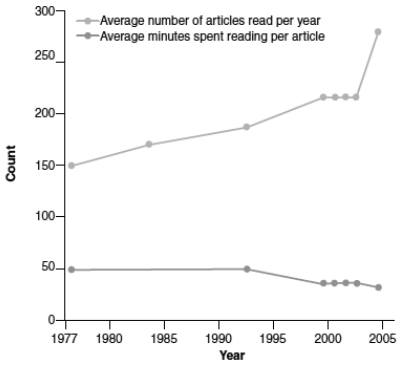
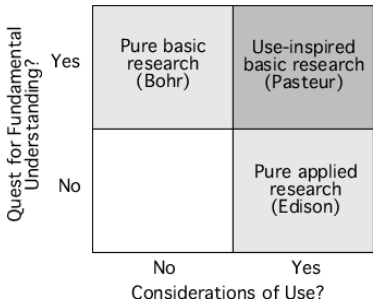


Fig. 2. Increase in the number of papers read by scientists per year and decrease in minutes spent reading each paper, trends based on a series of survey studies conducted by Tenopir *et al.* between 1977 and 2005 (*10*, *34*, *35*).

Science (2009) 325: 849

Emerging Issues

Interdisciplinarity



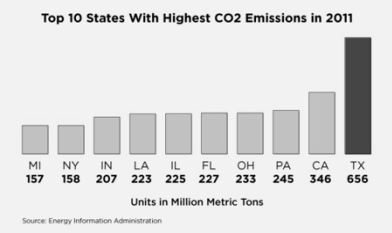
Pasteur's Quadrant

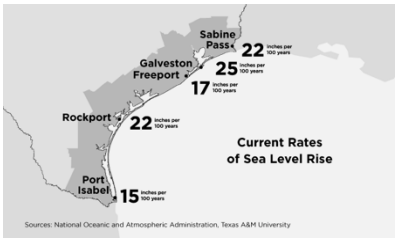
Stokes, 1997. Pasteur's Quadrant: Basic Science and Technological Innovation

Multidisciplinary: the juxtaposition of disciplines in an additive rather than integrative and interactive fashion, producing an encyclopedic alignment of multiple perspectives (Klein 2002).

Interdisciplinary: unrelated academic disciplines in a research project that forces them to cross subject boundaries. Collaborators integrate disciplinary knowledge in order to create new knowledge and theory and achieve a common research goal (Tress et al. 2006).

T-shaped Programs: Science & Policy





THE TEXAS TRIBUNE

Climate Scientists: Texas is Missing an Opportunity

by Neena Satija | July 13, 2014 | 15 Comments

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Enlarge photo by: Callie Richmond

Texas remains one of the most significant contributors to global warming in the world. Year after year, Texas spews out more greenhouse gases than any other state in the country.

FALLING BEHIND

Falling Behind is a 10-part series on the flip side of state leaders' aggressive pursuit of the "Texas Miracle." You can also read our related Hurting For Work series here, or subscribe to our water and education newsletters here.

*Correction appended

While Texas' Republican leadership touts the state's booming economic growth, Texas-based climate scientists — some of the world's most renowned — say that growth has come at a high cost.

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T-shaped Programs: Science & Policy

General sense that scientific knowledge is influencing policy and management.

- Environmental issues
  - Climate change
  - Ecosystem functioning
  - Risk assessment
  - Water resources
- *Is it a deeper chasm than just a communication gap?*

Daniel Smith, Political Science
New York Times Magazine, 9.4.05

nature

4 April 2002 Volume 416 Issue no 6880

Media studies for scientists

Science, with its inherent uncertainties, can be hard to put across to the public. But blaming 'sloppy' journalism is too easy. If researchers are to make their points effectively, they should learn more about how the media work.

No organization likes to feel the pressure of negative media coverage. Last year, when the Fred Hutchinson Cancer Research Center in Seattle was accused of mismanaging clinical trials, this bastion of the medical establishment found itself under an unwanted spotlight. Now the series of articles that made the allegations is a contender for the Pulitzer Prize, and those involved are reliving their media nightmare (see page 463).

Leading researchers and scientific bodies have rallied round the centre. This was bad journalism, say the critics. It seems like a familiar story: sloppy journalists misrepresent science.

How often does this happen? The cancer-centre story is a complicated and emotive one. But there is no doubt that science is, on occasion, badly covered in the media. Last week, for instance, one British newspaper ran a front-page story headlined "Scientists find Prozac 'link' to brain tumours". The lead author of the research told *Nature* that the story was "scandalous" — there is no epidemiological link. His study merely showed that the antidepressant could, in the test tube, prevent certain tumour cells from being triggered to commit suicide by the neurotransmitter serotonin.

Nevertheless, many scientists are quick to attack the media when they believe they have been misrepresented. And at conferences addressing the public understanding of science, journalists are often portrayed as the root of the problem.

This knee-jerk reaction itself misrepresents the way in which stories enter the media — journalists are not the only players. University press offices, in particular, must take some responsibility for hyped findings. Pushed by university leaders to maximize total coverage, press officers fill their releases with claims of significant breakthroughs. Scientists then complain when their work is hyped beyond its true worth.

Researchers could also examine how other professions manage the media. Politicians are misrepresented more frequently and significantly than scientists. But they know that attacking journalists is a short-sighted strategy. Instead, they have become experts in rebutting inaccurate stories and imparting their own message.

How far should scientists go down this road? Scientists, as with almost every other profession, enjoy more public trust than politicians. Gaining a reputation for spin could damage this. Researchers

Nature, 04.04.02

Emerging Issues

T-shaped Programs: Teaching & Learning

Scientific research can be transferred to the classroom through authentic inquiry:

- Scientific models & data sets
- Explicit description of cognitive and metacognitive skills
- New information technologies, research equipment, or tools
- Support communities of learning as content specialists.

Teaching through inquiry as a boundary object between research and teaching.

EDITORIAL

Rebalancing Teaching and Research

In universities across the United States and in many other parts of the world, the biological sciences continue to enjoy a wonderful revolution. Everything has changed in the research laboratory, but it is likely that far less has changed in the classroom down the hall. The same detachment of professor from student that frustrated university education 25 years ago is just as pervasive today. Although each course is now likely to have its own Web site, with class schedule, lecture notes, and assignments, the professoriate still struggles with how to use technology to achieve a greater impact on student learning and how to communicate the genuine excitement surrounding today's discoveries.

For this shortcoming we are paying a huge price: a decreasing percentage, here in the United States, of students who wish to pursue research careers; school districts that struggle to find qualified K-12 science teachers; and a public that has only a hazy understanding of the research advances that are sweeping through our society.

At the Howard Hughes Medical Institute (HHMI), we've recently empowered 20 outstanding teacher-scholars to make an impact on university education. These HHMI Professors, chosen through a nationwide competition,* are each being given $1,000,000 over 4 years to develop new modes of science teaching. Their approaches are diverse; in essence, they'll be carrying out 20 experiments in innovative education. Yet they share the common denominator of providing many more undergraduates with a real research experience. Other themes include teaching graduate students and postdocs how to teach; extending research experiences to high-school students and teachers; bridging biology with engineering, chemistry, and computer science; and engaging more underrepresented minorities in research.

How will their activities have a more general impact? The HHMI Professors will meet regularly to compare notes about what works in the classroom and what doesn't. Their best practices will then be broadly disseminated. We expect them to create Web- or DVD-based resources—including animations of biological processes and "virtual laboratories"—that encourage participatory learning. Furthermore, they will share successful curricula and materials by publishing in journals such as the new Web-based *Cell Biology Education*.†

For Jo Handelsman (right), a HHMI "million-dollar professor," research and teaching can't be separated.

Why do today's university faculty so rarely apply the same innovation and energy to their teaching that they invest in their research? There is no mystery here. Promotions, large salaries, and prestige at a research university are dependent on publications, patents, and grant funds. Good teaching may be appreciated, even applauded, but good research is at the heart of the reward structure. By providing recognition and research-level dollars to accomplished scientists who have a track record of exciting teaching and a penchant for more, we hope to tilt the research/teaching balance back to a healthy equilibrium.

These individual awards should enhance what is already going on at an institutional level. HHMI, the National Science Foundation, and others have nurtured undergraduate research through grants to both research universities and 4-year colleges for many years. Hands-on research experiences, though inherently inefficient with respect to faculty effort per student, are strikingly effective in their impact on young people's lives. We now have the opportunity to extend such experiences from independent research projects, often carried out by science majors in the junior or senior year, to core projects for many more students, preferably beginning much earlier in their undergraduate careers.

Reinvigoration of science teaching at research universities will benefit students, of course, but faculty will also find new stimuli for their research. G. N. Lewis's invention of the electron dot system for depicting chemical bonding while teaching introductory chemistry at the University of California, Berkeley, is a story that has been repeated with countless variations over the years. Students' questions force faculty to read and think outside their narrow field, often expanding or revising their approach to research problems. Above all, faculty members find great personal satisfaction in excelling at the activity that gives real meaning to the title "professor."

Thomas R. Cech

Thomas R. Cech is president of the Howard Hughes Medical Institute and for 22 years has been a teacher of undergraduates at the University of Colorado, Boulder.

*See www.hhmi.org. †See www.cellbioed.org and pubmedcentral.nih.gov.

www.sciencemag.org SCIENCE VOL 299 10 JANUARY 2003 165

Science, 10 January 2003

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Digital scholarship: Emerging roles of libraries

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Emerging Libraries

Changing Scholarly Practices

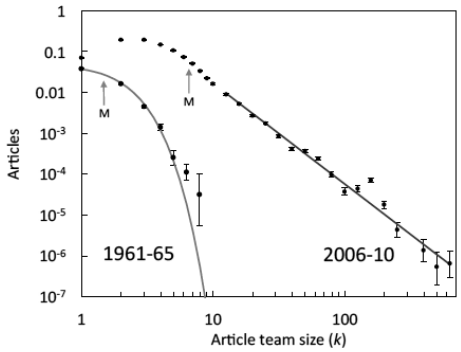

Fig. 1. Distribution of article team sizes in astronomy in two time periods separated by 45 y. The distribution from 1961 to 1965 is well described by

PNAS (2014) 111(11): 3984–3989

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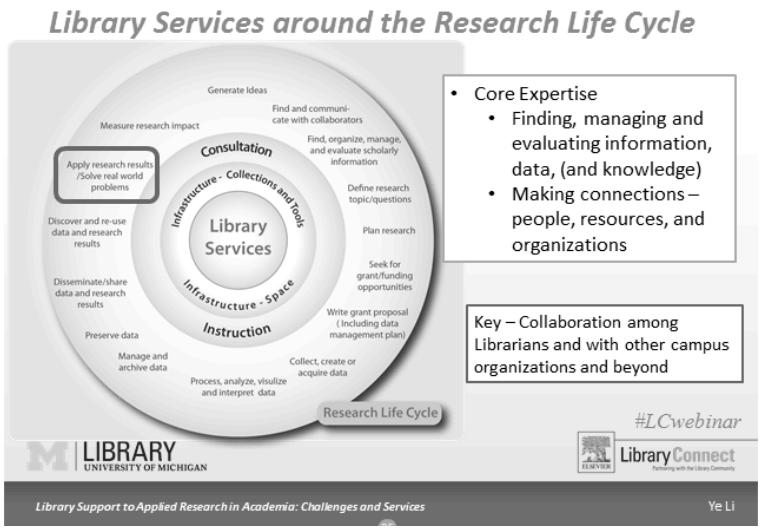
The Challenge

"… a key challenge remains: How can we curate and manage data now that so much of it is being produced and collected in digital form? How can we ensure that it will be discovered, shared, and reused to advance scholarship.

But changes in the *practice* of scholarship need to go hand in-hand with changes in the *communication* and *documentation* of scholarship."

– Clifford Lynch *Educause Review*

The Challenge



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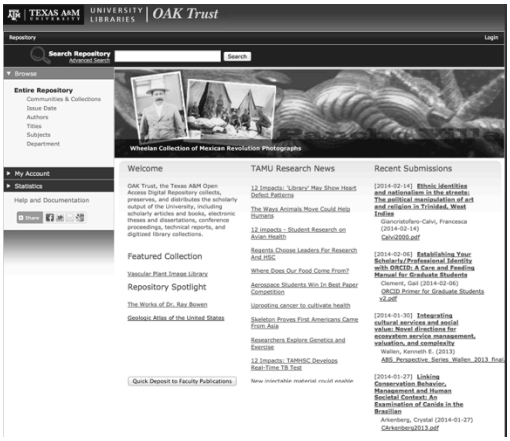
Emerging Libraries
TAMU Library Programs



http://repository.tamu.edu/

The TAMU Library Supports:

Tools to create data management plans

Publication repositories

OAK Fund

Data repositories (soon?)

http://guides.library.tamu.edu/DataManagement

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Emerging Libraries

Information Management

- Data as new library resource
- Curate research products
- Integrate tools and programs with research workflows

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Commentary

July 7, 2014

At Sea in a Deluge of Data

By Alison J. Head and John Wihbey

Most Popular

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1. College, on Your Own
2. Who Does Your College Think Its Peers Are?
3. What's So Funny?

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Emerging Libraries

Metaknowledge

SPECIAL SECTION

PERSPECTIVE

Metaknowledge

James A. Evans* and Jacob G. Foster

Extract understanding from collections

- Natural language processing
- Data mining
- Visualization of networks
- Identify location

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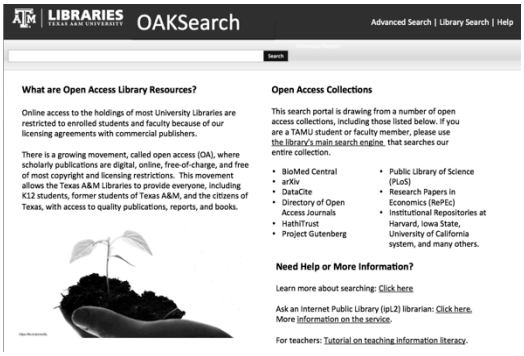
Emerging Libraries

Communicating Scholarship

- Allow scholarship to be repackaged – break copyright restrictions
- Improve accessibility
- Communicate research to address societal grand challenges



OA Search Portal for Roscoe ISD

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Final Thoughts

Innovative programs that bring about systemic change on campus through:

- Effective partnership with the campus
- Iterative design process that draws from the best practices of program design
- The organizational change frameworks of Bolman & Deal (2008)
  - Organizational frame
  - Human resource frame
  - Political frame
  - Symbolic frame

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