Building Community and Improving Leadership of Cyberinfrastructure Enterprise

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This background concept paper elaborates on the beliefs noted above:

- *Science enterprise is not fully represented in schools of administration – in either research or teaching.*
- *Future human enterprise will resemble science enterprise in key ways not now addressed in schools of administration.*
- *Cyberinfrastructure represents a special opportunity to understand science enterprise.*

Science Enterprise and Schools of Administration

"Science enterprise" refers to scientific or engineering efforts carried out in universities, laboratories, non-profit organizations, and in some cases for-profit companies that typically involve coordination of activities and resources across multiple projects. Science enterprises are becoming increasingly interdisciplinary, computationally intensive, and geographically distributed. Science enterprises are typically *not* aimed at specific product or service development. On the engineering side they are characterized more by "engineering science" and "experimental engineering" than by "design engineering" aimed at product or service development. Such enterprise usually is more formally organizational and institutionalized than a researcher's laboratory, is set up to last beyond any researcher's involvement with the work, and often provides specialized services that researcher laboratories cannot support.

"Schools of administration" refer to schools of business, management, public policy, public administration, and information. Schools like this seldom see science in terms of *enterprise,* but as an organizational function (*e.g.,* the research function in pharmaceutical companies) or a "sector" (*e.g.,* small drug design companies as part of the pharmaceutical R&D sector). Management and business schools deal primarily with for-profit organizations in competitive markets, organized largely around functions such as capital generation, human resource management, information systems, strategy, and so on. Public policy and public administration schools typically concern themselves with organized governmental activity as Weberian rational-bureaucratic action, and organize their work around policy analysis and professional administrative support of elected officials. Information schools focus on information issues that include scholarly communication, and focus on the administration of institutions historically important to the information professions (*e.g.,* libraries, archives, museums). Science enterprise tends to be marginalized in current schools of administration.[1]

[1] Other areas of focused administration (*e.g.,* health administration and educational administration) are handled either by schools focused on the domains (*e.g.*, health sciences, education) or as boutique programs in broader schools of administration.

Were science enterprises just like other kinds of enterprise this would not be a problem. But science enterprise is different. It is typically pre-competitive and does not fall clearly into the "for-profit" space, making it a poor fit for schools of business administration or management. It seldom makes or implements public policy, and does not administer government programs, making it a poor fit for schools of public policy and public administration. Information is important to science enterprise, but the work goes well beyond the institutions of interest to i-Schools. Science enterprise concentrates on knowledge discovery and application that might have implications for competition, profit, or public policy. However, these concerns follow rather than lead science enterprise.

Science enterprise exists within rules made by a larger organization – a university, a laboratory's home agency, or a company. The concern of the larger organization is to ensure that the science enterprise "contributes to the fulfillment of its mission" and "follows the rules" – does what it is supposed to do, remains in compliance with regulations, adheres to budget, etc. Science enterprise leaders seek to avoid conflict with its organization and other stakeholders, but they seldom turn to their institutions for advice on how to organize scientific enterprise. They typically have acquired *project management skills* that are good for running projects, but that are not sufficient to run an enterprise. General principles of administration can be helpful, and schools of administration provide them, but inadequate study of science enterprise creates major holes with respect to science enterprise *as enterprise* in its own right. This is lost value for science enterprise and for the society that benefits from that enterprise.

Science Enterprise and the Future of Enterprise

The leaders of science enterprise need help. Why should organization scientists provide such help? We argue that science enterprise has features important to the future of enterprise generally. Organization science and the schools of administration in which most organization scientists work can learn from studying science enterprise in three ways by viewing science enterprise as: (1) a unique kind of "knowledge organization;" (2) embodying next-generation, forward-looking work practices; and (3) involving intense but distributed collaborative work.

1. ***Science enterprise as "knowledge organization:"*** Science enterprise is exemplary of the "knowledge economy," which has often been suggested as the "way of the future" for organizations, generally. "Innovation" is at the heart of major shifts the behavior of capital markets, to take just one indicator. Apple Computer, with 50,000 employees, revolutionized entertainment (the iPod and iTunes) and telephony (the iPhone and its Apps). It is now among the most valuable corporation on Earth, outranking the former "blue chip" firm General Motors with 200,000 employees. Knowledge organizations are key to the future of innovation, and science enterprises are arguably the most knowledge-intensive forms of organization. Science enterprises operate at the edges of human knowledge – such enterprises specialize in extreme adaptation and agility.

Science enterprise is also essential to national welfare. Even in the United States, funding for science enterprise is growing despite downward pressure on national spending. Everything important is political, and science enterprise is increasingly political. It is grounded in experience of many decades, dating back to the origins of industrial organization and state bureaucracy in the 19th century. The careful study of science enterprise offers much of value to contemporary organizations and institutions.

2. ***Science enterprise and future work practices:*** Science enterprise has long used forms of production that might be part of future enterprise generally, including short-hold-time contracting (*e.g.,* working for limited time on experiments or papers with specific terms for each participant), intense collaboration over distance (*e.g.,* each of the major experiments at the Large Hadron Collider at CERN near Geneva involves more than 3,000 investigators from all over the world working together), multi-tasking (*e.g.,* university scientists usually do a combination of research, teaching, and administrative work, sometimes for their university and sometimes for other communities of practice), and constant surveillance to determine profit potential and likely social consequences (good and bad) from the work being done.

   Science enterprise is increasingly computationally intensive, pioneering trends such as visualization, big data, and open source software. Science enterprise is also "institutionally plural," operating in multiple institutional contexts simultaneously. This requires engagement with complicated circumstances imposed either by the environment (*e.g.,* the nature of the work itself) or by social forces (e.g., compliance expectations from institutional review boards). All this takes place in an environment of intense competition with other scientific enterprises and researchers, although not usually market-based competition.

3. ***Science enterprise and distributed work:*** Contemporary science enterprise requires action across organizational, institutional, and national boundaries on a frequent basis. Successful science enterprise requires working effectively in an immediate organizational or institutional environment as well as serving as a reviewer, conference organizer, association or society member, and adviser to other organizations or institutions. Science enterprise offers individuals freedom with respect to setting work schedules and priorities, but there is an expectation of long hours and high productivity. Science enterprise routinely works across boundaries of nations, communities, and increasingly, disciplines. Administratively interesting developments such as open-source software (*e.g.,* the Firefox web browser), crowdsourcing (*e.g.,* Amazon's Mechanical Turk), open-knowledge (*e.g.,* Wikipedia) – grow out of traditions of science enterprise.

Science enterprise, considered broadly, is not a marginal or boutique form of enterprise. It is an important guide for emerging enterprises of many kinds. Organization scientists who focus on the character of science enterprise have much to contribute to the study of other types of organizations, and to enterprise, generally.

Cyberinfrastructure and Science Enterprise

This workshop focuses on cyberinfrastructure centers. The NSF Office of Cyberinfrastructure funded this work, and those involved with the workshop are interested in cyberinfrastructure. Beyond this, we argue that cyberinfrastructure centers are useful points of entry to study of science enterprise because cyberinfrastructure is so important to the evolution of contemporary science.

Cyberinfrastructure is at the heart of changing practices in science enterprise. In some cases is cyberinfrastructure is required for science enterprise to progress. Many of the important advances in fields like elementary particle physics, meteorology, and materials science could not have happened without advanced cyberinfrastructure. Cyberinfrastructure is becoming more important throughout the science enterprise as technology and technique advance. Cyberinfrastructure is disruptive, changing the conduct of science enterprise. As realization of this has grown, cyberinfrastructure centers have been established.

Cyberinfrastructure centers often bridge between multiple communities of importance to science enterprise. Projects that require advanced cyberinfrastructure support (*e.g.,* beyond that available from desktop or laboratory equipment) must use cyberinfrastructure resources from local, regional, national or international cyberinfrastructure centers. This requires crossing borders, contracting for required support, and adherence to conventions and rules created by service providers. It often requires close interaction with experts in the cyberinfrastucture centers who know whether the technology can support a given project, and if so, what must be done to make that support successful. This support is usually idiosyncratic to the research being done. Arrangements for provision of these services must be made, implemented, and sustained in order for the work to progress. There are few commercial, off-the-shelf (COTS) solutions, so customized solutions are created that reveal much about the nature of science enterprise. Cyberinfrastructure centers are hotbeds research and development. This extends far beyond the experiments being done, and often producing new forms of engineering and computing, as well as new organizational, and institutional arrangements. Cyberinfrastructure centers are a good place to see the shock-of-the-new, and to learn how the new becomes routinized. For example, the World Wide Web that changed the way we live and work grew out of CERN and NCSA.

As the name implies, cyberinfrastructure is about *infrastructure*, which is embedded in activity and, once routinized, is often forgotten and sedimented upon over time. Attention to the lower levels of sedimented infrastructure occurs mainly when infrastructure breaks down and causes problems. Cyberinfrastructure centers create leading edge innovations that enable new science, but they are also stewards of established and essential infrastructure. They navigate the tension evident in all innovative realms associated with standards, platforms, and new capabilities. They offer an interesting and instructive example of science enterprise in which the "center" serves

as an essential part of the production system.[2] Their creation has raised objections that such activity drives out curiosity-driven, investigator-initiated research, but the trend has not slowed. The problems tackled by the science enterprise cannot be addressed without such centers, and the specialized services provided by some centers make this model the only practical solution. Large cyberinfrastructure centers, including those participating in this workshop (e.g., NCSA, SDSC, PSC, RENCI, NCIS, ALCF, NERSC, EMSL/MSCF) have been around for several decades. There is much knowledge to tap in such centers, but they have seldom been the focus of ongoing organizational research.

Conclusion

This workshop is predicated on the belief, reinforced by the results of prior workshops, that there is much to gain from collaboration between organization scientists and cyberinfrastructure center leaders. The benefits of this collaboration can accrue to both sides in the discussion. The objective of this workshop is to get beyond the general assumption that there is much to gain from collaboration, and to discuss in some detail what the stakeholders in this effort need and want from collaboration. We are willing to discuss and debate the beliefs articulated at the beginning of this document. After all, if we are wrong in those beliefs we need to re-think the mission of this work.

[2] For example, the NSF has created the Science and Technology Centers, the Engineering Research Centers, and the Learning Science Centers, while the National Institutes of Health has created the Comprehensive Cancer Centers and various Centers of Excellence. Similar focus on centers if found in many science-oriented agencies and organizations.

Questions

Please answer the following questions most relevant to your line of work and email responses to jlking@umich.edu by Monday, February 11. John King will compile the responses (without attribution) and make the results available to participants.

IF YOU ARE MAINLY IN CYBERINFRASTRUCTURE LEADERSHIP

1. What are the most serious challenges you and/or your organization face with respect to CI leadership? (No more than three; two or one OK.)
2. What, if any, "best practices" do you think your organization can contribute? (Brief description.)
3. Would you or any of your key people be interested in attending the "science executive education" sessions planned for this summer, assuming the content is aimed at your needs? (Yes or no.)
4. Any specific comments you'd like to make? (Entirely optional.)

IF YOU ARE MAINLY IN ORGANIZATION SCIENCE[3]

1. Do you generally accept the arguments made in the background concept paper regarding science enterprise and the future of enterprise? (Yes or No: detailed points can be argued)
2. Do you believe that there is something for organization science in the study of science enterprise? (Yes or No; elaborate if you wish)
3. Are you personally interested in working in this area in the future? (Yes or No is sufficient; this is not a contract, so your answer is not binding.)
4. Any specific comments you'd like to make? (Entirely optional.)

[3] If you don't see yourself in cyberinfrastructure leadership, assume you are in organization science. The term "organization science" is not elastic enough to take everyone, but we have invited people who are primarily cyberinfrastructure leaders or are not cyberinfrastructure leaders but are observers interested in organizations. Consider this dichotomy a "useful fiction" for the purposes of this workshop.