e-Sciences: Infrastructures that reshape the Global Contours of Knowledge

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Abstract. The contribution that e-Sciences make towards communicating and collaborating via networks will take many different forms, but it is argued here that the overall effect of these new tools will be to reshape the contours of scientific knowledge, creating a new divide between the visibility of online and offline knowledge. This divide points to the contribution that e-Sciences make towards the increasing globalization of scientific knowledge. Online scientific knowledge will also allow a more effective mapping of knowledge within different domains. This paper will locate e-Sciences within the broader intellectual and social organization of scientific knowledge.

Introduction

In recent years, there have a number of social science debates about globalization (Guillen 2001). At the same time, researchers nowadays often describe their research as having a global purview. Add to this that researchers are increasingly using online resources and it is clear that the nature of scientific knowledge is shifting. e-Sciences infrastructures take the use of electronic resources one step further since they provide new tools that are expressly designed to produce new structures for communication and collaboration via networks.[1] The sociology of science and technology can provide an account of how this reshaping of knowledge is taking place since it can put the new infrastructures into their social context – a context, it will be argued here, that has important global dimensions which include geography, organization, communication, and characteristics related to the content of knowledge.

Geography

The technology that underlies the global nature of e-Sciences is based on a worldwide system, the Internet/Web, which, like other communications infrastructures, spans the globe. Within this system, the factors that contribute to globalization include the global searchability of online sources and supra-national standards for accessing and storing material.

Although the content of the various e-Sciences efforts is different, there are also global similarities in structure and form, such as the setting up of national offices for the promotion of e-Sciences. This, too, follows patterns in other forms of organization of science, whereby

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[1] ‘e-Sciences’ is used here to indicate all efforts, including natural and social sciences, involving high-performance computing and powerful electronic networks, such as those under the aegis of the UK e-Science and the US cyberinfrastructure programmes.

nation-states have set up similar institutions in the course of development (Drori et al. 2003). It should therefore not be overlooked that one of the main forms of organization of e-Sciences is neither global nor local (based on individual e-Sciences initiatives) – but national. This is because the resources which fund large-scale research initiatives are mainly national. This national character of e-Sciences also follows historical precedent since ‘national systems of innovation’ (Edqvist 1997) have dominated research policy and ‘big science’(Galison and Hevly 1992), and ‘large technological systems’ (Hughes 1987) have also often been extended towards a national level. But in addition to the homology between them, national systems have also become ‘promiscuous’ in the sense that joining them together has become an important aim, which has simultaneously made the obstacles to this process more visible.

There are also factors that constitute barriers to the globalization of e-Sciences. These include the silo-ing of online material (national health databases), restrictive access and storage policies, different regimes for intellectual property rights, and the like. To this can be added commercial barriers such as boundaries created by security concerns and subscriber-only availability of online services. Nevertheless, the very possibility of being able to categorize the global and non-global settings of e-Sciences crystallizes the divide between the globalization of knowledge and how it remains tied to local (‘local’ in this case simply indicating particular sub-national geographical settings, or boundaries between private and public access) and national settings. Whereas previously, the globalization of science had been seen mainly in terms of the diffusion of institutions (Drori et al. 2003), we can now add to this the diffusion of tools and the world-wide development of national systems and open access policies which support global links between organizations and networks.

Organization

One aspect of the reorganization of knowledge in e-Sciences are the growing number of worldwide organizations devoted to promoting e-Sciences, some building on existing global institutions (the ‘open science’ initiatives already mentioned), some coming together in new collaborative agreements (for example, between the NSF and EPSRC/ESRC), and some forming new global communities (Grid computing conferences). This aspect of globalization is part of a wider trend towards supranational coordination efforts among non-governmental organizations to address a variety of political and economic issues (Slaughter 2004), but also scientific and technological ones (Drori et al. 2003). In short, there are some e-Sciences organizational initiatives which aim to span across the globe organizationally, in addition to the world-wide institutional isomorphisms in the organization of e-Sciences that have already been mentioned.

A different aspect of the reorganization of knowledge is that e-Sciences are not based in conventional disciplines. They typically involve a number of disciplines, but at a minimum involve two disciplines; computer science plus a domain specific science. Furthermore, e-Sciences initiatives often entail inter-institutional collaboration and other types of alliances that cross institutional and disciplinary boundaries, even if they face considerable obstacles (Cummings and Kiesler 2005). Though, as Nentwich (2003) has shown, the extent to which different disciplines have embraced e-Sciences varies, and is not necessarily, as might be expected, along the natural science versus social science versus humanities divide.

When these patterns are combined they constitute a major change in the landscape of knowledge production: In the past, research was housed in departments, research institutes and disciplines. Now, they are often housed in inter-institutional organizations and e-Sciences application domains which support and are supported by technological infrastructures. Again, this reshaping of boundaries also makes visible the obstacles to this reshaping.

Communication

Scientific communication is in principle ‘open’ (Fuchs 2001, 2002). The implication is that the cultural, disciplinary, political, economic or other boundaries that beset other social networks are transcended by scientific communication. In the case of e-Sciences, this ‘openness’ is combined with the fact that e-infrastructures are online and in this sense more readily accessible than offline scientific modes of communication. The requirement to communicate in the sciences, to publish one’s findings in order to be recognized, cuts across all the channels for scientific communication and disciplines (Becher and Trowler 2001). And although different rules for publication exist in different media, different disciplines and different settings, being first to publish an idea or produce an innovation is thus a ‘global’ filter.

The main constraint on scientific communication is the limited attention space (Collins 1998: 37-40) in each medium of knowledge dissemination. The electronic resources devoted to e-infrastructures - research reports, papers, project descriptions and the like (for example, http://www.scienceofcollaboratories.org/) must vie with each other for attention in the larger scientific community just like other (non- e-Sciences) scientific results, though they will be at the leading edge of scientific advance insofar as they couple novel technological artifacts with discovery (see below, and Collins 1994). Organizationally, different disciplines are, as Whitley (2000) has argued, coupled in different ways to their task (‘uncertainty’) and in terms of the extent to which researchers are dependent on each other. In the case of the e-Sciences, this dependence or coupling has shifted online such that different efforts must integrate and coordinate their online resources.

Knowledge

Technological infrastructures are an example of Collins’s argument that novel technological artifacts drive the advance of scientific knowledge – rather than the other way around. New technological development has led to ‘high-consensus rapid-discovery’ science (Collins 1994 and 1998: 532-38). The leading edge of this advance at any point in time tends to be concentrated in particular research areas; namely, where artifacts and knowledge are coupled in novel ways. And in several places, e-Sciences exemplify this novel coupling.

Extending this argument to e-infrastructures entails recognizing, however, that these infrastructures comprise of a variety of tools, with different effects for different domains of knowledge. It has been argued that e-Sciences shift boundaries in different disciplinary domains in different ways (see the contributions in Hine 2006), but it can equally be argued that there is also one continuous boundary, between online and offline sciences. This cumulative impact of e-Science extends to all the areas affected by the new technological artifacts because e-Sciences, like other ‘big science’ efforts and developments of large technological systems, have a momentum of their own (Hughes 1994). Nevertheless, the allocation of resources devoted to research and different areas of research is limited, and so policies for research funding and research policy generally are bound to impact on this advance, pushing it further in some cases than in others.

The ability to create new tools does not necessarily mean, however, that there will be a closer coupling between knowledge and technologies on one side - and tasks and the real world on the other. New technologies add to and complement, rather than replacing and superseding, previous ones. Still, inasmuch as e-Sciences are closely coupled to certain tasks, they will capture the attention of researchers (and publics) who are directed towards the domain of the advance. Infrastructures provide a focus, but they are only one area of knowledge production among others, again, competing for attention amidst the sciences as a whole. Yet scientific knowledge and technological development are global in the further sense that there is only ever *one* leading edge for a given domain of phenomena. The limited attention space, apart from this leading edge competition, means that in addition to intra-scientific priority (competition to be first, including publication), there is an extra-scientific factor - public attention - which selects, or provides a mechanism for, how research is prioritized.

The ‘migration’ between different fields (Fuchs1992: 189) makes it difficult to identify where current scientific advances are taking place. As with the sciences as a whole, the main reason why the global nature of knowledge is hidden from view is because there is a fragmented and limited attention space which acts as a gatekeeper. This fragmentation is counteracted by other trends, and in particular recent innovations in scientometrics whereby knowledge is mapped by means of electronic tools. Thus scientific ‘output’ - its volume, scope, and degree to which it is made use of or accessed, which, together, give an indication of ‘migration’ – is increasingly quantified and analyzed more effectively because the information is in electronic form (Shiffrin and Boerner 2004).

Examples of e-Sciences Contributions to Globalization

	Type	Dimension of Globalization	Contribution to Globalization	Reference
AstroGrid	Astronomy Research Project	Communication, knowledge	Standardized interfaces and resources	www.astrogrid.org
Virtual Observatory for the Study of Online Networks (VOSON)	Social Science Research Project to study online activism	Geography	Scope of phenomena investigated	http://voson.anu.edu.au
Integrative Biology (IB)	Interdisciplinary Biology Research Project	Geography, organization	Global collaboration and distributed visualization	www.integrativebiology.ac.uk
Global Grid Forum (GGF)	Organization to promote global standards for grid computing	Organization, communication	Standards	www.ggf.org
Open Access Publishing	Free access to online publications and resources	Communication	Access to knowledge	www.ssrn.com, Nentwich (2003: 229 and passim)

Table 1. Examples of Global Features of e-Sciences

In this short space, it is only possible to mention a few examples of e-Sciences projects which highlight the different dimension of globalization (geography, organization, communication, and (content of) knowledge that have been discussed (table 1). These contributions towards globalization are not mutually exclusive; only the most obvious dimensions of the contributions of various e-Sciences efforts towards globalization are highlighted here.

The mistake in regarding e-Sciences (or science in general) as inescapably tied to particular (less-than global) social contexts is to think of globalization as all-or-nothing. Instead, the contribution of e-Sciences to globalization consists of many incremental steps by means of which the global nature of this part of scientific advance emerges in different ways: in part, for example, it consists of a physical network that spans the globe; other parts consist of the resources (the content) that represent the most up-to-date available data within a particular area of scientific knowledge, and organizational collaboration and forms of communication represent still other parts, whether by means of large technological systems or repositories of data.

Science cannot be global once-and-for-all inasmuch as its leading edge is always provisional – but this is simply part of the open and restlessly advancing nature of science and technology in-the-making as a whole. Thus the flipsides to all these examples are the constraints on current e-Sciences. Do all e-Sciences efforts contribute therefore to globalization? No, because many parts of e-Sciences efforts will turn out not to contribute to the advance of interlocking between computing tools and the physical and natural worlds. Nevertheless, there is cumulative effect of these changes, including a shift online *and* a simultaneous shift towards a more global science.

Conclusion: Frontiers and Limits of e-Science and Globalization

The technological – electronic - mediation of scientific advance is becoming an ever more globally visible part of scientific knowledge with the increasing shift to online resources. The shift towards concentrating on the development of online infrastructures is bound to shift the focus of attention onto advances that have an e-Sciences presence which, in turn, will transform the disciplinary landscape. At the same time, this process is constrained by the competition between different e-Sciences efforts. As resources for research are scarce, there is a need to prioritize among scientific areas. On the one hand, it is therefore important to recognize the various limits to global research that have been pointed to here, and that have been made more visible. This recognition of limits may make it possible to better direct research organization. On the other hand, it can be recognized that e-Sciences have developed a momentum of their own, and in this sense the globalization of scientific knowledge brought about by e-infrastructures, and the contribution that all e-Sciences efforts make towards making knowledge more manipulable, is bound to continue.

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