What Internet Use Does and Does not Change in Scientific Communities

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This article examines the supposedly new social phenomena produced by internet use in the scientific community that has been discussed in the literature and tackles the question of which social structures and practices are actually changing. This serves as a background against which to assess new phenomena. Since the internet's main impact obviously concerns the transmission of data and information, a theoretical perspective on the way scientific communities produce knowledge and on the role of communication in that process is developed. It can be demonstrated that the internet leaves the social order of scientific communities unchanged but affects the mode of production of some scientific communities by providing opportunities for a communalization of raw data analysis, data production, and external contributions.

Keywords: scientific communities, e-science, electronic publishing

Internet and Science

The internet creates new social phenomena at a very rapid pace, but the question whether these phenomena are sociologically new is often difficult to answer. The emergence of new *empirical* objects of research does not necessarily imply that these objects constitute new *theoretical* objects for sociological research. From a theoretical perspective, the interesting question about the internet is whether (or to what extent) new forms of social order will emerge. The pessimistic observer may argue that the new means of communication has had negligible effects. All patterns of social interactions and relations that are currently being observed have existed before the internet and continue to exist in the offline-world independent of the internet (e.g. Calhoun, 1998). More optimistic observers may argue that new patterns are emerging. This has been suggested, for example, for open source software production (Raymond, 1999; Dalle and Jullien, 2003), for the trade with free goods and services in the internet (Ghosh, 1998), and more generally for a distinct "form of social integration" that is "carried" by the internet (Holmes, 1997: 27).

Supposedly new social structures triggered by the internet have been reported in several science studies. Hilgartner (1995) has discovered "new communication regimes" in molecular biology that have emerged with online databases (see also Kling and McKim, 2000). Wellman *et al.* (1996) equate virtual communities with "computer-supported social networks" and regard scientific communities as "dispersed work teams" (Wellman *et al.*, 1996: 227). Gresham (1994) contributed the concept "cyberspace college", while Walsh and Roselle (1999) have coined the term "virtual college". Others apply the term "collaboratories" to a supposedly new form of global collaboration of geographically dispersed scientists which has been enabled by the internet (Glasner, 1996; Finholt and Olson, 1997).

This abundance of new phenomena and concepts raises suspicions. While it is certainly true that the internet changes communication practices in science, the race for new concepts is liable to be missing the persistence of more general structures behind the phenomena. The aim of this paper is to investigate the new phenomena that have been reported in the literature and to ask which social structures and practices are actually changing. This undertaking requires a theoretical understanding of how scientific communities 'traditionally' function, to serve as a background against which new phenomena can be assessed. Since the internet's main impact obviously concerns the transmission of data and information, a theoretical perspective on the way scientific communities produce knowledge and on the role of communication in that process will be developed. On the basis of this conceptual clarification it becomes possible to assess the internet's impact on the production of scientific knowledge. I will demonstrate that the internet leaves the social order of scientific communities unchanged but affects the mode of production of some scientific communities. The discussion will be concluded with some propositions about general new trends that are caused by the internet.

Production and Communication in Scientific Communities

The production of scientific knowledge has been traditionally regarded as a collective enterprise. This idea can be traced back to Fleck ([1935] 1979) and is part of the writings of Merton ([1942] 1973), Barber (1952), Polanyi (1962), Kuhn (1962), and most recently of Ziman (2002). However, all these references to the collective enterprise are surprisingly fuzzy. While the authors state that scientists contribute to a common product (scientific knowledge), they are reluctant to describe precisely how this common product is created, how individual actions are coordinated, how social order is maintained etc. This is one of the reasons why the sociology of science has developed only weak ties to general sociological theory.

The basic obstacle to a systematic description of collective production in scientific communities for all these approaches is that they are burdened with concepts that emphasize individual production and subsequent exchange. First, most of the analysts of collective phenomena are concerned with the reasons why scientists produce new knowledge at all. Incentives for contributing new knowledge are either found in an intrinsic motivation to advance knowledge, or are defined via an exchange theory which regards scientists as exchanging new knowledge for some kind of recognition as provided by colleagues' references to their work (Hagstrom, 1965). Second, social order in science is seen as emerging from the scientific ethos, i.e. from a set of norms which govern all scientists' actions and interactions. Scientists offer new knowledge to the community, and this new knowledge is accepted and added to the common stock of knowledge by the community. These assumptions are ultimately locating the production of new knowledge with the individual: individuals produce new knowledge and circulate it, and as members of the community they decide about truth and recognition for new knowledge claims.

These ideas make it difficult to envisage a collective knowledge production process because they implicitly rest on a separation of the creation of knowledge claims, which appears to be a local activity, from the knowledge claims' later fate in the community's actions, which is supposed to be a global phenomenon. This separation is at odds with the concept of collective production because it fails to explain how scientists manage to produce contributions that fit together, and why so few of the newly produced knowledge claims are recognized at all.

Meanwhile, ethnographic observations have involuntarily demonstrated that the scientific community controls what is going on in the laboratory. While the sociology of scientific knowledge (SSK) aimed at showing "in concrete detail the ways in which the making, maintaining, and modification of scientific knowledge is a local and mundane affair" (Shapin, 1995: 304), the ethnographic records unveil the ubiquitous influence of the community and the body of knowledge that is shared by its members. This concerns the formulation of problems (Knorr-Cetina, 1981: 49-50, 52-55; Latour and Woolgar, [1979] 1986: 112-124), the means to approach them (Knorr-Cetina, 1981: 63-64; Bazerman, 1988: 245-247), and the criteria to distinguish 'real' from artifactual results (Lynch, 1985: 92-101). Also the publication of new knowledge claims is not an individual activity. Even in the case of non-collaborative research drawing up a publication involves not only the author but also trusted assessors (Chubin, 1975), editors, and reviewers, who all influence the content of the publication – either directly or via the author's anticipation of their response (Knorr-Cetina, 1981: 101-112; Myers, 1990: 65-66, 75-80). Finally, at least in some fields communication via publications is accompanied by a constant stream of other information that is incorporated in research materials, laboratory protocols etc. (Cambrosio and Keating, 1988; Hilgartner, 1997), not to mention the continuous informal communication between scientists.

Thus, the suggestion of two distinct spheres of knowledge production seems to be a reification created by both the Mertonian focus on the scientific community's formal communication and the SSK's focus on local knowledge creation. If we suspend the concepts 'scientific ethos' and 'exchange of contributions for recognition', and if we read the ethnographic records disregarding their intended local focus, it becomes clear that scientific communities are indeed collectively producing communities. Coordination of actions is achieved by scientific knowledge rather than norms, namely by the community's shared body of knowledge.[1] Scientists derive problems and methods of problem solving from their interpretation of the common body of knowledge. They produce knowledge claims that are offered to the community to be added to the common body of knowledge. Integration is accomplished by other scientists using the offered new knowledge, i.e. treating it as belonging to the common body of knowledge. As citation studies show, many offers are discarded. Most articles are cited only once or are not cited at all (Cole and Cole, 1972; Stern, 1990; Seglen, 1992).

Scientific communities thus represent a distinctive mode of collective production which is characterized by decentralized action coordination via local interpretations of the shared subject matter of work (Gläser, 2001b, 2002).[2] This decentralized coordination of contributions can be termed *distributed* labor, as opposed to *division* of labor that is organized ex ante by a centralized agency. The same mode of coordination has been observed by Moon and Sproull (2000) in open source software development, and has been termed "distributed work".[3] A community whose production is coordinated decentrally can operate without knowledge about all active or even potential participants. This is important because membership in scientific communities is established by perception: Whoever uses a community's body of knowledge in her production of new knowledge perceives herself as a member of the community. Membership can even be established by others' perceptions: Whoever offers knowledge that is used in a community's production process is regarded as a member of this community. Membership based on perception and attribution is the reason why the whole mode of production hinges on publication of contributions. Only by publication can the offers of new knowledge be addressed to an unknown audience.

This understanding of scientific communities provides a basis for revisiting the role of communication in collective knowledge production. It becomes clear that communication in science is not a separate circulation of previously produced knowledge.[4] It is rather part of the production process, namely the transmission of material and components between producers. Similarly, the citation process is a work flow rather than a cash flow. Citation links new knowledge claims to existing ones and thereby indicates subsequent processing of knowledge claims. The crucial difference between research and (most) other production processes is that in research information is simultaneously material, component and product of work. Moving material, components and products around is a constitutive part of the production process. This is not to say that strategic communication about intentions, interests, and activities of actors is ruled out in science. However, this type of communication must be analytically separated from the knowledge production process.

Old and New Practices in the Production of Scientific Knowledge

What is not New

The internet does not change the social order of scientific communities, i.e. the ways membership is established, actions are coordinated. But it may trigger other changes, many of which have been proposed in the literature. I will begin by demonstrating that some of the proposed new phenomena are not new at all. In the subsequent section, I will discuss new phenomena that may change the way in which scientific knowledge is produced.

Apparently the internet has significantly enhanced the opportunities of scientists to communicate knowledge. As a result existing practices of communication have been augmented but a radically new practice of scientific work has not emerged. While, for instance, email communication is frequently used by scientists its impact on collaboration is by no means revolutionary. Merz (1997) reports that theoretical physicists rely heavily on electronic communication and that an increasing number of trans-local collaborations can be observed. However, theoretical physicists still emphasize the importance of face to face contacts. Most collaborative projects that are conducted via email (an opportunity provided by the specific subject matter and methods of theoretical physics) are initiated face to face (Merz, 1997: 323). Increasing collaboration may not just be caused by email because the geographical mobility of theoretical physicists has increased, too (Merz, 1997: 316). Merz concludes that "e-mail interaction is not a substitute for travelling and face to face interaction". Similarly, Walsh and Roselle (1999) have found that while electronic communication accelerates collaborative research and promotes geographically more dispersed collaborations, the work organization has not changed, and face to face communication remains important. These observations clearly contradict the ambitious title of their article "Computer Networks and the Virtual College", because they provide no evidence that such a college exists. A quantitative study of the impact of computer-mediated communication on collaboration associates greater use of computer-mediated communication with more and more highly interdependent collaboration as well as higher productivity (Walsh *et al.*, 2000). However, it is difficult to establish causation here because both directions of causation (frequent email use increases collaboration versus more collaboration increases email use) are possible.

A similar case can be made for the informal communication that accompanies the application of experimental methods. Hine (2002) has investigated the communication of a newsgroup devoted to "laboratory talk" of biologists, i.e. to the exchange of know how. Scientists who encounter difficulties when applying specific methods post their question to the newsgroup and get advice from their colleagues. Hine observed that scientists act openly (i.e. apparently revealing their identity), and that the exchanges involve highly esoteric, context dependent shop talk, typical of practicing scientists. This kind of communication has always been an important part of scientists' everyday work

(Collins and Harrison, 1975; Lynch, 1985; Cambrosio and Keating, 1988) and represents a specific type of collaboration ('exchange of know-how', Laudel, 2001). The main difference that is made by an internet-based newsgroup is that the request for help can be sent much more quickly to a wider audience. What was previously achieved either by phone calls or by conversations at conferences is now achieved by a message that is sent to several hundred colleagues at the same time.

None of these changes actually affects the way scientific knowledge is produced. This holds true for publication practices, too. A detailed analysis of the "continuum of electronic publishing" shows that the common claim that e-publishing "substantially expands access" is oversimplified (Kling and McKim, 1999). In accordance with the model of collective production, Kling and McKim (1999: 905) state "that scholarly communication can be conceptualized as a communicative practice anchored in three dimensions: *publicity, access, and trustworthiness*." They show that electronic documents made available via the internet do not necessarily reach high publicity, nor are they always easy to access. Their trustworthiness depends on classic 'off-line' characteristics, namely an author's reputation or peer review. Today the scarcest resource is not journal space but the attention of readers. Therefore, a transition from paper-based to electronic publishing is not likely to change the way scientific knowledge is produced. As is the case with personal communication, the internet makes things easier, faster and more global, but it has not qualitatively changed the social order of scientific communities or the way scientific knowledge is produced.

What is New

At the current stage the internet makes scientists' life easier and their work faster but it does not change the *content* of work. As has been shown in the previous section, the content, procedures and importance of communication have not been qualitatively changed by the new communication channels. Similarly, peer-reviewed, regularly published electronic journals bear too much resemblance to traditional paper journals to be a revolutionary new development. A similar case can be made for collaboration networks supported by electronic communication.

There are, however, new developments that have the potential to significantly change the way scientific work is conducted in at least some scientific communities. We observe a rapidly growing number of online databases which provide public access to experimental and observational data. These databases seem to trigger new communication practices (Hilgartner, 1995; Kling and McKim, 2000). A second new phenomenon is the emergence of "collaboratories" – networks of geographically dispersed scientists who communicate, collaborate and share data via the internet (Glasner, 1996; Finholt and Olson, 1997). While it has been shown in the previous section that many of the supposedly new collaboration practices are in fact traditional ones that use a new technical medium, there is an undoubtedly new element in these collaboratories, namely remote access to experimental equipment. Thirdly, remote access to computing capacity outside science has occurred but has gained little attention in the literature.

A) Online Databases Containing Raw Data

Scientific communities in molecular biology and biomedicine have begun to store their raw data (gene sequences) in online databases. This practice has emerged because several practices came into conflict. One of the general norms in science is that scientific publications must contain the data that are used to substantiate knowledge claims. With sequencing tools becoming more and more powerful, journals in the field received more and more sequence data and started to become reluctant to publish them. After negotiations between database managers and journals, a new practice was established: submitting data to a publicly accessible database became a requirement for publication (Hilgartner, 1995: 250-254). Kling and McKim (2000: 1308) give an account of several cases of databases in molecular biology that contain heterogeneous data about model organisms.[5] Outside molecular biology there exist plans to create a database with raw data on the movements and diving behaviour of dolphins, whales, seals and other marine animals (Knight, 2002). Online databases also exist in the social sciences (see http://www.academicinfo.net/socdata.html for an overview of databases).

These databases are seen by some authors as new communication regimes. Kling and McKim treat them as a distinct type of "electronic communication forums", which they call "digital disciplinary corpora" (Kling and McKim, 2000: 1309). Similarly, Hilgartner (1995: 257) states that "the construction of biomolecular databases has become an occasion for introducing a variety of new communication regimes". He compares these new regimes to journals (Hilgartner, 1995: 244-250). Thus, publicly accessible databases appear as a new practice of communicating knowledge by publication.

The difficulty with this comprehension is that traditional and new publication practices are implicitly presupposed to have the same functions in research processes. Hilgartner (1995: 241) observes that "most of the data produced by scientists engaged in genome mapping and sequencing will never be published in conventional journals but will find their ultimate home in databases" without even raising the question to what extent this trend is caused by attributes of those data. Kling and McKim (2000) list electronic databases among several forms of electronic communication forums but do not discuss the roles of each of the "e-media" in scientific work.

In fact, the two practices differ significantly from one another. The main difference between publications and submissions to databases is that publications contain *knowledge claim*s, while databases contain *raw dat*a. Publications often include data but they are only reported to the extent that is necessary to support the knowledge claims. When raw data are submitted to a public data base, they are no longer exclusively connected to a few knowledge claims in a publication. As part of the database they now provide an independent basis for the construction of new knowledge claims, which can be used by all scientists who have access to the database.

Since raw data are created in an earlier stage of the knowledge production process, their public accessibility means that communalization is occurring in an earlier stage of knowledge production.

In this sense these databases can have a significant impact on knowledge production. Firstly, public databases provide a new basis on which knowledge can be established. If databases are not accessible researchers can base knowledge claims only on their own data and on all published knowledge. With access to databases the researchers can use all raw data they regard as relevant independent of their prior usage. Secondly, the opportunities to control the quality of published knowledge are enhanced in several ways. Selective use of data (e.g. exclusively of data that are supportive to the knowledge claims) can be more easily detected. While data production (of experimental conduct) still cannot be controlled via the new databases, the quality of data processing and the conclusions drawn from these data can now be tested. Moreover, conflicts over knowledge claims that rest on contradicting data can be more easily identified (albeit not necessarily more easily solved). Thirdly, by publishing raw data researchers lose the competitive advantage which usually results from exclusive use of unpublished data.[6] Attempts to create databases with unpublished data therefore meet resistance (Knight, 2002). Finally, these databases may initiate the emergence of a separate theoretical work in many scientific fields where it does not yet exist. The increasing amount of publicly accessible raw data enables the construction of knowledge claims solely on the basis of others' experiments. Searching for patterns in the data may become a distinct research activity, which would be similar to the "phenomenologists" in theoretical physics (Merz and Knorr-Cetina, 1997: 73)

These are significant changes that will affect work practices on all levels of scientific communities and therefore warrant detailed investigation. A combination of observations on two levels seems necessary. In-depth studies of changing work practices in laboratories are necessary to reveal the impact of databases. Possible effects are changing uses of and references to raw data, the emergence of new roles and new patterns of differentiation of laboratory work and also a more rigid divide between data production and data analysis. In order to catch the macro-effects of publicly accessible databases on the scientific community comparative observations of local practices and communication processes in different laboratories are required. Changing work practices will be indicated by the patterns and content of communication and publication that is related to the sharing of raw data.

B) Remote Access to Research Equipment

A second important aspect is that the internet facilitates remote access to research equipment. This allows scientists to directly control research instruments in order to produce the data they are interested in (cf. Science, 1998; Finholt and Olson, 1997). A weaker form of remote access is the real-time observation of high energy physics experiments via the net from all places in the world (Kling *et al.*, 2000). Even though they cannot intervene directly they may electronically get in touch with the laboratory and ask for interventions.

These observations support the view that the internet removes all barriers to access to research equipment. However, research equipment is rare and operation time is a scarce resource. Researchers who want to use such equipment usually have to approach the laboratory that controls the instruments and to ask for time and support to operate them. In high energy physics there is a well-established procedure for granting access to research equipment. Researchers apply for beamtimes, and a panel of their peers decides if the proposed experiment is worth the beamtime. The same criteria that govern the assignment of beamtimes in the offline world (scientific merits, rank of applying scientists, rank of their fields etc.) can be expected to operate when remote access is at stake. The internet cannot do away with scarcity of operating time.

Thus, it currently remains unclear if new social structures emerge because of remote acces to research equipment. The "collaboratories" described by Finholt and Olson (1997) make collaboration easier, faster, may include more collaborators and may even make collaboration more often successful – but do new social patterns emerge? Also, remote access is likely to change work practices qualitatively only where the physical access to the equipment but not the equipment's operating time is the scarce resource. Such cases would be very interesting because they represent a communalization in an even earlier stage of knowledge production. It would then not be a communalization of the creation of contributions to the shared knowledge (as in the classical case of publication), nor a communalization of raw data analysis (as in the case of databases), but a communalization of data production.

C) Remote Access to 'Research' Equipment Outside Science

While research equipment in science is usually scarce, there is abundance of equipment outside science that can be used as research equipment. Scientists have begun to exploit the unused computing capacity installed all over the world by including laypeople in their work. The Website Folding@Home (http://folding.stanford.edu) explains its practice as follows

> Folding@Home is a distributed computing project which studies protein folding, misfolding, aggregation, and related diseases. We use novel computational methods and large scale distributed computing, to simulate timescales thousands to millions of times longer than previously achieved. This has allowed us to simulate folding for the first time, and to now direct our approach to examine folding related diseases.

People who want to help the researchers at Stanford University may download software that uses a share of their computers' computing time to calculate protein structures. Useful results emerge after a relatively short time, are transmitted to the researchers via the internet and can be integrated in the overall project.[7]

This is an example of remote access to the enormous computing capacity that has been globally installed, and a significant part of which is interlinked by the internet. In terms of knowledge production, two interrelated changes of work practices can be observed. Firstly, the scientists have enhanced their resource base by integrating laypeople's resources into their work. They have designed a knowledge production process that extends beyond the boundaries of their scientific community. While laypeople have always contributed to science, in the case of protein folding the internet has made possible a new way to contribute, and has created a qualitatively new level of external contributions. Secondly, there is a remarkable difference between the 'distributed work' mode of production of a scientific community, the traditional integration of laypeople in a community's scientific work, and the "distributed computing" of Folding@home. The distributed work of scientific communities rests on the decentralized definition of tasks by community members. In the case of distributed computing, a community structure emerges because people share their computers to the folding problem. However, the production of data rests on an ex ante-division of labor, and the owners of computing time are completely passive with regard to goal formulation, definition of standards etc. No negotiations and no "boundary objects" (Star and Griesemer, 1989) are necessary to achieve the integration of results. Therefore, it is not possible to regard the 'amateur folders' as part of a producing community. Nevertheless we can regard these processes as a communalization of external contributions.

Conclusion

This article has discussed whether and how the internet has changed the social order of scientific communities and the way scientific knowledge is produced. The discussion is based on the concept of scientific communities as knowledge producing collectivities.The social order of collective production in scientific communities is not affected by the internet. Scientific communities are producing communities which share knowledge. This knowledge could be accessed publicly before the internet emerged. The communities use a variety of channels for informal day-to-day communication because communication has always been a necessary precondition of collaboration. Face-to-face interactions remain an important element in scientific work. The internet affects the relative importance of communication channels and makes communication and access to information easier and faster. It also helps to integrate new and more partners into the networks of collaboration. But qualitative changes in the work practices and social structures of scientific communities cannot be observed. Studies of supposedly new phenomena created by the internet tend to miss that point because they limit their focus to the new phenomena and do not compare them to 'pre-internet' practices.

Nevertheless, as the internet facilitates new work practices some qualitative changes in the process of collective knowledge production are likely to occur. In particular internet access to raw data may lead to such changes. Sharing raw data in open databases will lead to a communalization of raw data analysis, i.e. to a communalization of knowledge production at an earlier stage. While the provision of remote access to research equipment is apparently bound to very specific conditions that are not likely to occur in many scientific communities, it cannot be ruled out completely. A scientific community's remote access to research equipment would lead to a communalization of data production, i.e. to a communalization at a still earlier stage of knowledge production. Finally, there are a few significant attempts to establish remote access to equipment outside science that is turned into research equipment. This process leads to a communalization of external contributions to scientific knowledge. Thus, the internet provides additional means for sharing knowledge, using equipment and distributing work which will very likely trigger some qualitative changes in the process of collective production of scientific knowledge.

The extent to which these new communalization processes will affect scientific communities depends on the specific mode of knowledge production in these communities. Communalization of raw data analysis can be introduced in many natural and social science fields. Online databases containing raw data appear to be useful whenever many members of a scientific community work with the same research objects, and when the data describes attributes of these shared research objects. Such data has a multitude of uses and is of interest to the whole community. Communalization of data production appears to be a much more specific case, which can occur only in scientific communities which rely on *rare* equipment whose operation time is *not* scarce. This presupposition excludes the social sciences and many natural science fields that conduct 'small science'. Communalization of external contributions develops depending on the demand for computing time and on opportunities to solve the problems by distributed computing. Both characteristics can be expected to occur only in natural science fields.

The ease with which scientific communities have integrated the internet into their work practices leads to the conclusion that the internet facilitates the mode of production employed by scientific communities. Since the internet can easily provide public access to knowledge, it appears to be an ideal medium for distributed knowledge production. This mode of production is not necessarily restricted to scientific (or, in the case of open source, technical) knowledge. Therefore, a variety of internet-based knowledge producing communities may emerge. How this mode of production will extend beyond the production of knowledge remains to be studied.

Notes

1 This was a potential innovation in Kuhn's account of the dynamics of science that did not come to the fore. Kuhnian SSK remained in the institutional tradition by interpreting the paradigm normatively, i.e. as knowledge-turned-into-norms (Shapin, 1995: 301). The idea that scientific knowledge is a functional equivalent for norms in that it can co-ordinate human actions as knowledge was first proposed by (Böhme, 1975). Recently, a similar proposal has been made by Ziman (2002). However, Ziman fails to see that a paradigm does not contain enough information to co-ordinate scientists' ongoing research. This function can only be fulfilled by a scientific community's whole body of current scientific knowledge.

2 The consequences of this model for the theory of social order are discussed in Gläser (2001a).

3 Other authors, who compare open source communities and scientific communities,

do not realize the similarities but rather emphasize the differences in both types of community (Dalle and Jullien, 2003: 4). The authors' distinction between "creation and disclosure" and "distribution" – the very same quasi-economic approach that has confused science studies - prevents them from identifying the structure of collective production.

4 According to Böhme (1975: 206) scientific communication is argumentation and "the coherence of communication is the coherence of an argumentative context". It is not simply an exchange of information.

5 A detailed description of one of these databases (the "worm community system") is given by Glasner (1996: 112-113).

6 Data withholding is a common practice in science, especially in highly competitive fields such as biomedicine (Cohen, 1995; Blumenthal *et al.*, 1997; Hilgartner, 1998).

7 A second example is the project SETI@home (http://www.seti.org/) that searches for extraterrestial intelligence by applying a similar approach.

References

Barber, B.
1952 Science and the Social Order. New York: Macmillan Press.

Bazerman, C.
1988 Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science. Madison: The University of Wisconsin Press.

Blumenthal, D., Campbell, E.G., Anderson, M.S., Causino, N., & Seashore Louis, K.
1997 "Withholding research results in academic life science - Evidence from a national survey of faculty." Jama-Journal of the American Medical Association 277: 1224-1228.

Böhme, G.
1975 "The Social Function of Cognitive Structures: A Concept of the Scientific Community Within a Theory of Action." Pp. 204-221 in Knorr, K.D., Strasser, H. & Zilian, H.G. (eds.), Determinants and Controls of Scientific Development. Dordrecht: Reidel.

Calhoun, C.
1998 "Community without Propinquity Revisited: Communications Technology and the Transformation of the Urban Public Sphere." Sociological Inquiry 68: 373-397.

Cambrosio, A. & Keating, P.
1988 "Going Monoclonal": Art, Science, and Magic in the Day-to-Day use of Hybridoma Technology. Social Problems 35: 244-260.

Chubin, D.E.
1975 "Trusted Assessorship in Science: A Relation in Need of Data." Social Studies of Science 5: 362-368.

Cohen, J.
1995 "Share and share alike isn't always the rule in science; many researchers fail to share materials." Science 268: 1715-1718.

Cole, J.R. & Cole, S.
1972 "The Ortega Hypothesis." Science 178: 368-375.

Collins, H.M. & Harrison, R.G.
1975 "Bulding a TEA Laser: The Caprices of Communication." Social Studies of Science 5: 441-450.

Dalle, J-M. & Jullien, N.
2003 "'Libre' Software: turning fads into institutions?" Research Policy 32: 1-11.

Finholt, T.A. & Olson, G.M.
1997 "From Laboratories to Collaboratories: A New Organizational Form for Scientific Collaboration." Psychological Science 8: 28-36.

Fleck, L.
[1935] 1979 Genesis and Development of a Scientific Fact. Chicago: The University of Chicago Press.

Ghosh, R.A.
1998 "Cooking pot markets: an economic model for the trade in free goods and services on the internet." First Monday 3: http://www.firstmonday.org/issues/issue3_3/ghosh/index.html.

Gläser, J.
2001a ‘Producing Communities’ as a Theoretical Challenge. Paper presented at the TASA 2001 Conference, Sydney, Australia, Dec 13-15.
2001b “Scientific specialties as the (currently missing) link between scientometrics and the sociology of science.” Pp. 191-210 in Davis, Mari and Wilson, Concepción S. (eds.), Proceedings of the 8th International Conference on Scientometrics & Informetrics. Sydney, Australia, July 16-20th: BIRG, UNSW.
2002 Communities, not individuals or organisations, produce scientific knowledge. Paper presented at the ISA XVth World Congress of Sociology, Brisbane, 7th - 13th July 2002. Unpublished Manuscript.
Glasner, P.
1996 “From community to ‘collaboratory’? The Human Genome Mapping Project and the changing culture of science.” Science and Public Policy 23: 109-116.
Gresham, J.L.
1994 “From Invisible College to Cyberspace College: Computer Conferencing and the Transformation of Informal Scholarly Communication Networks.” Interpersonal Computing and Technology: An Electronic Journal for the 21st Century 2: 37-52.
Hagstrom, W.O.
1965 The Scientific Community. Carbondale: Southern Illinois Univ. Press.
Hilgartner, S.
1995 “Biomolecular Databases: New Communication Regimes for Biology?” Science Communication 17: 240-263.
1997 “Access to Data and Intellectual Property: Scientific Exchange in Genome Research.” Pp. 28-39 in National Research Council (ed.), Intellectual Property Rights and the Dissemination of Research Tools in Molecular Biology: Summary of a Workshop held at the National Academy of Sciences, February 15-16, 1996. Washington: National Academy Press.
1998 “Data Access Policy in Genome Research.” Pp. 202-218 in Arnold Thakray (ed.), Private Science - Biotechnology and the Rise of the Molecular Science. Philadelphia: University of Pennsylvania Press.
Hine, C.
2002 “Cyberscience and social boundaries: the implications of laboratory talk on the Internet.” Sociological Research Online 7: U79-U99.
Holmes, D.
1997 “Virtual Identity: Communitites of Broadcast, Communities of Interactivity.” Pp. 26-45 in Holmes, David (ed.), Virtual Politics: Identity and Community in Cyberspace. London: Sage.
Kling, R., & McKim, G.
1999 “Scholarly Communication and the Continuum of Electronic Publishing.” Journal of the American Society for Information Science 50: 890-906.
2000 “Not Just a Matter of Time: Field Differences and the Shaping of Electronic Media in Supporting Scientific Communication.” Journal of the American Society for Information Science 51: 1306-1320.
Kling, R., McKim, G., Fortuna, J. & King, A.
2000 Scientific Collaboratories as Socio-Technical Networks: A Theoretical Approach. http://www.arxiv.org/abs/cs.CY/0005007.
Knight, J.
2002 “Online marine resource could soon be swimming with data.” Nature 415: 4.
Knorr-Cetina, K.D.
1981 The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science. Oxford: Pergamon Press.
Kuhn, T.
1962 The Structure of Scientific Revolutions. Chicago: The University of Chicago Press.
Latour, B., & Woolgar, S.
[1979] 1986 Laboratory Life: The Construction of Scientific Facts. Princeton: Princeton University Press.

Laudel, G.
2001 "Collaboration, creativity and rewards: why and how scientists collaborate." International Journal of Technology Management 22: 762-781.
Lynch, M.
1985 Art and Artifact in Laboratory Science: A Study of Shop Work and Shop Talk in a Research Laboratory. London: Routledge & Kegan Paul.
Merton, R.K.
[1942] 1973 "The Normative Structure of Science." Pp. 267-278 in Merton, Robert K. (ed.), The Sociology of Science. Chicago: The University of Chicago Press.
Merz, M.
1997 "'Nobody Can Force You When You Are Across the Ocean' - Face to Face and E-Mail Exchanges Between Theoretical Physicists." Pp. 313-329 in Agar, Ion and Smith, Crosbie (eds.), Making Space for Science. London: St. Martins Press.
Merz, M. & Knorr-Cetina, K.
1997 "Deconstruction in a 'thinking' science: Theoretical physicists at work." Social Studies of Science 27: 73-111.
Moon, J.Y. & Sproull, L.
2000 "The Essence of distributed Work: The Case of the Linux Kernel." First Monday 5, http://firstmonday.org/issues/issue5_11/moon/index.html.
Myers, G.
1990 Writing Biology: Texts and The Social Construction of Scientific Knowledge. Madison: The University of Wisconsin Press.
Polanyi, M.
1962 "The Republic of Science." Pp. 1-20 in Shils, Edward (ed.), Criteria for Scientific Development: Public Policy and National Goals. Cambridge: Massachusetts Institute of Technology.
Raymond, E.
1999 "The Cathedral and the Bazaar." Knowledge, Technology & Policy 12: 23-49.
Science
1998 "Microscopy Across an Ocean." Science 281: 303.
Seglen, P.O.
1992 "The Skewness of Science." Journal of the American Society for Information Science 43: 628-638.
Shapin, S.
1995 "Here and Everywhere - Sociology of Scientific Knowledge." Annual Review of Sociology 21: 289-321.
Star, S.L. & Griesemer, J.R.
1989 "Institutional Ecology,'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." Social Studies of Science 19: 387-420.
Stern, R.E.
1990 "Uncitedness in the Biomedical Literature." Journal of the American Society for Information Science 41: 193-196.
Walsh, J.P. & Roselle, A.
1999 "Computer Networks and the Virtual College." Pp. 49-78 in OECD (ed.), Science Technology Industry Review (24).
Walsh, J.P., Kucker, S., Maloney, N. & Gabbay, S.M.
2000 "Connecting Minds: Computer-Mediated Communication and Scientific Work." Journal of the American Society for Information Science 51: 1295-1305.
Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, M. & Haythornthwaite, C.
1996 "Computer Networks as Social Networks: Collaborative Work, Telework, and Virtual Community." Annual Review of Sociology 22: 213-238.
Ziman, J.
2002 Real Science: What it is, and what it means. Cambridge: Cambridge University Press.

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