The Ethnography of Infrastructure

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This article asks methodological questions about studying infrastructure with some of the tools and perspectives of ethnography. Infrastructure is both relational and ecological—it means different things to different groups and it is part of the balance of action, tools, and the built environment, inseparable from them. It also is frequently mundane to the point of boredom, involving things such as plugs, standards, and bureaucratic forms. Some of the difficulties of studying infrastructure are how to scale up from traditional ethnographic sites, how to manage large quantities of data such as those produced by transaction logs, and how to understand the interplay of online and offline behavior. Some of the tricks of the trade involved in meeting these challenges include studying the design of infrastructure, understanding the paradoxes of infrastructure as both transparent and opaque, including invisible work in the ecological analysis, and pinpointing the epistemological status of indictors.

> Resources appear, too, as shared visions of the possible and acceptable dreams of the innovative, as techniques, knowledge, know-how, and the institutions for learning these things. Infrastructure in these terms is a dense interwoven fabric that is, at the same time, dynamic, thoroughly ecological, even fragile.
>
> —Bucciarelli, 1994, p. 131

> Tell that its sculptor well those passions read
> Which yet survive, stamped on these lifeless things.
>
> —Percy Bysshe Shelley, 1817

GENERAL METHODOLOGICAL PROBLEMS

This article is in a way a call to study boring things. Many aspects of infrastructure are singularly unexciting. They appear as lists of numbers and technical specifications, or as hidden mechanisms subtending those processes more familiar to social scientists. It takes some digging to unearth the dramas inherent in system design creating, to restore narrative to what appears to be dead lists.

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Bowker and Star (in press) note of the International Classification of Diseases (ICD), a global information-collecting system administered by the World Health Organization,

> Reading the ICD is a lot like reading the telephone book. In fact, it is worse. The telephone book, especially the yellow pages, contains a more obvious degree of narrative structure. It tells how local businesses see themselves, how many restaurants of a given ethnicity there are in the locale, whether or not hot tubs or plastic surgeons are to be found there. (Yet most people don't curl up with a good telephone book of a Saturday night.)

They note that aside from this direct information, indirect readings of such dry documents can also be instructive. In the case of phone books, for instance, a slender volume indicates a rural area; those that list only husband's names for married couples indicate a heterosexually-biased, sexist society.

Historical changes are important in reading these documents. Names and locations of services may change with political currents and social movements. Bowker and Star (in press) note that,

> In the Santa Cruz, California, phone book, Alcoholics Anonymous and Narcotics Anonymous are listed in emergency services; years ago they would have been listed under "rehabilitation" if at all. The changed status reflects the widespread recognition of the organizations' reliability in crisis situations, as well as acceptance of their theory of addiction as a medical condition. Under the community events section in the beginning, next to the Garlic Festival and the celebration of the anniversary of the city's founding, the Gay and Lesbian Pride Parade is listed as an annual event. Behind this simple telephone book listing lies decades of activism and conflict—for gays and lesbians, becoming part of the civic infrastructure in this way betokens a kind of public acceptance almost unthinkable 30 years ago . . . excursions into this aspect of information infrastructure can be stiflingly boring. Many classifications appear as nothing more than lists of numbers with labels attached, buried in software menus, users' manuals, or other references.

Much of the ethnographic study of information systems implicitly involves the study of infrastructure. Struggles with infrastructure are built into the very fabric of technical work (Neumann & Star, 1996). However, it is easy to stay within the traditional purview of field studies: talk, community, identity, and group processes, as now mediated by information technology. There have been several good studies of multiuser dungeons (MUDs), or virtual role-playing spaces, distance-mediated identity, cyberspace communities, and status hierarchies. There are much fewer on the effect of standardization or formal classification on group formation, the design of networks and their import for various communities, or on the fierce policy debates about domain names, exchange protocols, or languages.

Perhaps this is not surprising. The latter topics tend to be squirreled away in semi-private settings or buried in inaccessible electronic code. Theirs is not the

usual sort of anthropological strangeness. Rather, it is an embedded strangeness, a second-order one, that of the forgotten, the background, the frozen in place.

Studies of gender bending in MUDs, of anonymity in decision making, and new electronic affiliations *are* important; they stretch our understanding of identity, status, and community. The challenges they present are nontrivial methodologically. How does one study action at a distance? How does one even observe the interaction of keyboard, embodied groups, and language? What are the ethics of studying people whose identity you may never know? When is an infrastructure finished, and how would we know that? How do we understand the ecology of work as affected by standardization and classification? What is universal or local about standardized interfaces? Perhaps most important of all, what values and ethical principles do we inscribe in the inner depths of the built information environment (Goguen, 1997; Hanseth & Monteiro, 1996; Hanseth, Monteiro, & Hatling, 1996)? We need new methods to understand this imbrication of infrastructure and human organization.

As well as the important studies of body snatching, identity tourism, and transglobal knowledge networks, let us also attend ethnographically to the plugs, settings, sizes, and other profoundly mundane aspects of cyberspace, in some of the same ways we might parse a telephone book. My teacher Anselm Strauss had a favorite aphorism, "study the unstudied." This led him and his students to research in understudied areas: chronic illness (Strauss, 1979), low-status workers such as janitors, death and dying, and the materials used in life sciences including experimental animals and taxidermy (Clarke & Fujimura, 1992). The aphorism was not a methodological perversion. Rather, it opened a more ecological understanding of workplaces, materiality, and interaction, and underpinned a social justice agenda by valorizing previously neglected people and things.

The ecological effect of studying boring things (infrastructure, in this case) is in some ways similar. The ecology of the distributed high-tech workplace, home, or school is profoundly impacted by the relatively unstudied infrastructure that permeates all its functions. Study a city and neglect its sewers and power supplies (as many have), and you miss essential aspects of distributional justice and planning power (Latour & Hermant, 1998). Study an information system and neglect its standards, wires, and settings, and you miss equally essential aspects of aesthetics, justice, and change. Perhaps if we stopped thinking of computers as information highways and began to think of them more modestly as symbolic sewers, this realm would open up a bit.

DEFINING INFRASTRUCTURE

> What can be studied is always a relationship or an infinite regress of relationships. Never a "thing." (Bateson, 1978, p. 249)

People commonly envision infrastructure as a system of substrates—railroad lines, pipes and plumbing, electrical power plants, and wires. It is by definition invisible, part of the background for other kinds of work. It is ready-to-hand. This image holds up well enough for many purposes—turn on the faucet for a drink of water and you use a vast infrastructure of plumbing and water regulation without usually thinking much about it.

The image becomes more complicated when one begins to investigate large-scale technical systems in the making, or to examine the situations of those who are *not* served by a particular infrastructure. For a railroad engineer, the rails are not infrastructure but topic. For the person in a wheelchair, the stairs and doorjamb in front of a building are not seamless subtenders of use, but barriers (Star, 1991). One person's infrastructure is another's topic, or difficulty. As Star and Ruhleder (1996) put it, infrastructure is a fundamentally relational concept, becoming real infrastructure in relation to organized practices (see also Jewett & Kling, 1991). So, within a given cultural context, the cook considers the water system as working infrastructure integral to making dinner. For the city planner or the plumber, it is a variable in a complex planning process or a target for repair: "Analytically, infrastructure appears only as a relational property, not as a thing stripped of use" (Star & Ruhleder, 1996, p. 113).

In my own research, this became clear when I did fieldwork over 3 years with a community of biologists, in partnership with a computer scientist who was building an electronic shared laboratory and publishing space for them (Schatz, 1991). I was studying their work practices and traveling to many laboratories to observe computer use and communication patterns. Although we were following the principles of participatory design—using ethnography to understand the details of work practice, extensive prototyping, and user feedback; testing the system in laboratories and at conferences—few biologists ended up using the system. It seemed the difficulty was not in the interface or the representation of the work processes embedded in the system, but rather in infrastructure—incompatible platforms, recalcitrant local computing centers, and bottlenecked resources. We were forced to develop a more relational definition of infrastructure, and at the same time, challenge received views of good use of ethnography in systems development.

We began to see infrastructure as part of human organization, and as problematic as any other. We performed what Bowker (1994) has called an "infrastructural inversion"—foregrounding the truly backstage elements of work practice. Recent work in the history of science (Bowker, 1994; Edwards, 1996; Hughes, 1983, 1989; Summerton, 1994; Yates, 1989) has begun to describe the history of large-scale systems in precisely this way. Whether in science or in the arts, we see and name things differently under different infrastructural regimes. Technological developments move from either independent or dependent variables, to processes and relations braided in with thought and work. In the Worm Community Study, Ruhleder and I came to define *infrastructure* as having the following properties, with examples following each dimension.

Embeddedness. Infrastructure is sunk into and inside of other structures, social arrangements, and technologies. People do not necessarily distinguish the several coordinated aspects of infrastructure. In the Worm study, our respondents did not usually distinguish programs or subcomponents of the software—they were simply "in" it.

Transparency. Infrastructure is transparent to use, in the sense that it does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks. For our respondents, the task of using ftp to download the system was new and thus difficult; for a computer scientist, this is an easy, routine task. Thus, the step of using ftp made the system less than transparent for the biologists, and thus much less usable.

Reach or scope. This may be either spatial or temporal—infrastructure has reach beyond a single event or one-site practice. One of the first things we did in system development was scan in the quarterly newsletter of the biologists so that one of the long-term rhythms of the community could be emulated online.

Learned as part of membership. The taken-for-grantedness of artifacts and organizational arrangements is a *sine qua non* of membership in a community of practice (Bowker & Star, in press; Lave & Wenger, 1991). Strangers and outsiders encounter infrastructure as a target object to be learned about. New participants acquire a naturalized familiarity with its objects, as they become members. Although many of the objects of biology were strange to us as ethnographers, and to the computer scientists, and we made a special effort to overcome this strangeness, it was easy to overlook other things that we had already naturalized, such as information retrieval practices over networked systems.

Links with conventions of practice. Infrastructure both shapes and is shaped by the conventions of a community of practice (e.g., the ways that cycles of day-night work are affected by and affect electrical power rates and needs). Generations of typists have learned the QWERTY keyboard; its limitations are inherited by the computer keyboard and thence by the design of today's computer furniture (Becker, 1982). The practices of reporting quarterly via the newsletter could not be changed in the biologists' system—when we suggested continual update, it was soundly rejected as interfering with important conventions of practice.

Embodiment of standards. Modified by scope and often by conflicting conventions, infrastructure takes on transparency by plugging into other infrastructures and tools in a standardized fashion. Our system embodied many standards used in the biological and academic community such as the names and maps for genetic strains, and photographs of relevant parts of the organism. But other

standards escaped us at first, such as the use of specific programs for producing photographs on the Macintosh.

Built on an installed base. Infrastructure does not grow *de novo*; it wrestles with the inertia of the installed base and inherits strengths and limitations from that base. Optical fibers run along old railroad lines; new systems are designed for backward compatibility, and failing to account for these constraints may be fatal or distorting to new development processes (Hanseth & Monteiro, 1996). We partially availed ourselves of this in activities such as scanning in the newsletter and providing a searchable archive; but our failure to understand the extent of the Macintosh entrenchment in the community proved expensive.

Becomes visible upon breakdown. The normally invisible quality of working infrastructure becomes visible when it breaks: the server is down, the bridge washes out, there is a power blackout. Even when there are back-up mechanisms or procedures, their existence further highlights the now-visible infrastructure. One of the flags for our understanding of the importance of infrastructure came with field visits to check the system usability. Respondents would say prior to the visit that they were using the system with no problems—during the site visit, they were unable even to tell us where the system was on their local machines. This breakdown became the basis for a much more detailed understanding of the relational nature of infrastructure.

Is fixed in modular increments, not all at once or globally. Because infrastructure is big, layered, and complex, and because it means different things locally, it is never changed from above. Changes take time and negotiation, and adjustment with other aspects of the systems are involved.[1] Nobody is really in charge of infrastructure. When in the field, we would attempt to get systems up and running for respondents, and our attempts were often stymied by the myriad of ways in which lab computing was inveigled in local campus or hospital computing efforts, and in legacy systems. There simply was no magic wand to be waved over the development effort.

INFRASTRUCTURE AND METHODS

The methodological implications of this relational approach to infrastructure are considerable. Sites to examine then include decisions about encoding and standardizing, tinkering and tailoring activities (see, e.g., Gasser, 1986; Trigg & Bødker, 1994), and the observation and deconstruction of decisions carried into infrastructural forms (Bowker & Star, in press). The fieldwork in this case transmogrifies to a combination of historical and literary analysis, traditional tools like interviews and observations, systems analysis, and usability studies. For example, in studying the development of categories as part of information infrastructure, I observed meetings of nurses striving to categorize their own work

(Bowker, Timmermans, & Star, 1995), studied the archives of meetings at the World Health Organization and its predecessors arguing about establishing and refining categories used on death certificates, and read old newspapers and law books recording cases of racial recategorization under apartheid in South Africa (Bowker & Star, in press). In each case, I brought an ethnographic sensibility to the data collection and analysis: an idea that people make meanings based on their circumstances, and that these meanings would be inscribed into their judgments about the built information environment.

I have also worked with computer scientists designing complex information systems. I began this work as a kind of informant about social organization. At first, the computer scientists sought examples of real organizational problem solving in order to model large-scale artificial intelligence systems. They identified problems from the realm of complex system development, and asked me to investigate their analog in organizational settings, primarily of scientists and engineers (Hewitt, 1986; Star, 1989). For example, when designers tried to model how a smart system would determine closure for a complex problem, I investigated how this was managed in 19th-century England by a group of neurophysiologists debating the functions of the brain (Star, 1989), and made formal models of the processes that were fed back to the computer scientists.

This early work began in the 1980s, before the current development in information systems partnering ethnographers with computer scientists for the purpose of improving usability (as, for example, in the Worm Community Study). During the last decade, some ethnographers have created durable partnerships with system developers in many countries, especially in the areas of computer-supported cooperative work (CSCW) and human-computer interaction (Bowker, Star, Turner, & Gasser, 1997). This work has emerged from a number of intellectual traditions, including ethnomethodology, symbolic interactionism, labor process research, and activity theory (cultural-historical psychology), among others.

All of us doing this work have begun to wrestle with questions of scalability that inherently touch on questions of infrastructure. It is possible (sort of) to maintain a traditional ethnographic research project when the setting involves one group of people and a small number of computer terminals. However, many settings involving computer design and use no longer fit this model. Groups are distributed geographically and temporally, and may involve hundreds of people and terminals. There have always been inherent scale limits on ethnography, by definition. The labor-intensive and analysis-intensive craft of qualitative research, combined with a historical emphasis on single investigator studies, has never lent itself to ethnography of thousands.[2]

At the same time, ethnography is a tempting tool for analyzing online interaction. Its strength has been that it is capable of surfacing silenced voices, juggling disparate meanings, and understanding the gap between words and deeds. Ethnographers are trained to understand viewpoints, the definition of the situation. Intuitively, these seem like important strengths for understanding the

enormous changes being wrought by information technology. The scale question remains a pressing and open one for methodological concerns in the study of infrastructure. It is an ironic and tempting moment—we have the promise of a complete transcript of interactions, almost ready-made "fieldnotes" in the form of transaction logs and archives of e-mail discussions. At the same time, reducing this volume of material to something both manageable and analytically interesting is a tough nut to crack, despite the emergence of increasingly sophisticated tools such as Atlas/ti for qualitative analysis. Yet, I know of no one who has analyzed transaction logs to their own satisfaction, never mind to a standard of ethnographic veridicality (see Spasser, 1998, for a good discussion of some of these problems).

And we are still stuck with the problem of where online interactions fit with people's lives and organizations off-line. In the Worm Community Study, I tried simply to scale up traditional fieldwork techniques—and I and my research partner ended up traveling to dozens of labs, doing entrée work for each one, interviewing more than a hundred biologists, and exhausting myself in the process. In the Illinois Digital Library Project, our social science evaluation team found that we had to transform our original study of "emergent community processes in the digital library" (via fieldwork and transaction logs) to a linked set of interviews with potential users and ethnographies of the design team while we waited for the system testbed to emerge, some 2 years behind schedule (Bishop et al., in press; Neumann & Star, 1996). We had to invent new ways of triangulating and bootstrapping along with the systems developers. These new ways of working broke old forms both for our respondents and for us.

TRICKS OF THE TRADE[3]

The following section examines several tricks I have developed in the previously mentioned studies, helpful for "reading" infrastructure and unfreezing some of its features.

IDENTIFYING MASTER NARRATIVES AND "OTHERS"

Many information systems employ what literary theorists would call a master narrative, or a single voice that does not problematize diversity. This voice speaks unconsciously from the presumed center of things. An example of this encoding into infrastructure would be a medical history form for women that encodes monogamous traditional heterosexuality as the only class of responses: blanks for "maiden name" and "husband's name," blanks for "form of birth control," but none for other sexual practices that may have medical consequences, and no place at all for partners other than husband to be called in a medical emergency. Latour (1996) discusses the narrative inscribed in the failed metro system, *Aramis*, as encoding a particular size of car based on the presumed nuclear

family. Bandages or mastectomy prostheses labeled "flesh colored" that are closest to the color of White people's skin are another kind of example.

Listening for the master narrative and identifying it as such means identifying first with that which has been made other, or unnamed. Some of the literary devices that represent master narratives include creating global actors, or turning a diverse set of activities and interests into one actor with a presumably monolithic agenda ("the United States stands for democracy"); personification, or making a set of actions into a single actor with volition ("science seeks a cure for cancer"); passive voice ("the data have revealed that"); and deletion of modalities. The latter has been well-described by sociologists of science—the process by which a scientific fact is gradually stripped of the circumstances of its development, and the attendant uncertainties, and becomes an unvarnished truth.

In the previously mentioned study of the International Classification of Diseases, Bowker and I discovered many moments when the master narrative-in-the-making became visible. One such deconstructive moment occurred when a committee of statisticians attempted to codify the "moment of life": How can you tell, for the purposes of filling out a birth certificate, when a baby is alive? Religious differences (as, for example, between Catholics and Protestants) were argued about, as well as phenomenological distinctions such as the number of breaths a baby would draw, try to draw, or fail to draw (Bowker & Star, in press). In studies we read of the actual practices of filling in death certificates, the distinctions made by the "designers" upstream did not match the ways that attending doctors saw the world. We came to understand how the blanks on the forms were both heteropraxial (different practices according to region, local constraints, beliefs) and heteroglossial (inscribing different voices in the seemingly monotonous form).

SURFACING INVISIBLE WORK

Information systems encode and embed work in several ways. They may directly attempt to represent that work. They may sit in the middle of a work process like a rock in a stream, and require workarounds in order that interaction proceed around them. They also may leave gaps in work processes that require real-time adjustments, or *articulation* work, to complete the processes.

Finding the invisible work in information systems requires looking for these processes in the traces left behind by coders, designers, and users of systems (Star & Strauss, 1999, discuss this in relation to the design of CSCW systems). In some instances, this means going backstage, in Goffman's (1959) terms, and recovering the mess obscured by the boring sameness of the information represented. It is often in such backstage work that important requirements are discovered. For example, in the Worm Community Study, we discovered that there were crucial moments in a biologist's career—especially during the postdoc period, just before getting one's own lab—where secrecy and professional

smoothness are valued over the usual community norms of sharing preliminary results in semiformal venues.

With any form of work, there are always people whose work goes unnoticed or is not formally recognized (cleaners, janitors, maids, and often parents, for instance). Where the object of systems design is to support all work, leaving out what are locally perceived as "nonpeople" can mean a nonworking system. For example, with the biologists, I had originally wanted to include secretaries in the publication and communication stream, as they were so obviously (to me) part of the community communications. This was strongly resisted by both biologists and systems developers, as they did not see the secretaries as doing real science, and thus the idea was dropped. There is often a delicate balance of this sort between making things visible and leaving things tacit. With the nurses previously mentioned, whose work was categorizing all the tasks done by nurses, this was an important issue. Leave the work tacit, and it fades into the wallpaper (in one respondent's words, "we are thrown in with the price of the room"). Make it explicit, and it will become a target for hospital cost accounting. The job of the nursing classifiers was to balance someone in the middle, making their work just visible enough for legitimation, but maintaining an area of discretion. Without the fieldwork at their sessions where they were building the classification system, Bowker, Timmermans, and I (1995) would never have known about this conflict.

PARADOXES OF INFRASTRUCTURE

Why does the slightest small obstacle often present a barrier to the user of a computer system? One of the findings of our studies of users in the Illinois Digital Library Project (Bishop et al., in press) is that seemingly trivial alterations in routine, or demands for action, will act to prevent them from using the system. This can be an extra button to push, another link to follow to find help, or even looking up from the screen. The obduracy of these "tiny" barriers presents, at first glance, a puzzle in human irrationality. Why would someone not punch a couple of buttons rather than walk across campus to get a copy of something? Why do people persist in using less functional, but more routine actions when cheaper alternatives are nearby? Are people so routinized, so rigid in their ability to adapt to change that even such a slight impediment is too much?

Rather than characterize human nature with such broad strokes, I return to a fieldwork example for an explanation of this phenomenon. At a phenomenological level, what has happened is that these slight impediments have become magnified in the flow of the work process. An extra keyboard stroke might as well be an extra 10 pushups. What is going on here?

One way to explain this magnification process is to understand that in fact two processes of work are occurring simultaneously: Only one is visible to the traditional analysis of user-at-terminal or user-with-system. That is the one that concerns keystrokes and functionality. The other is the process of assemblage,

the delicate, complex weaving together of desktop resources, organizational routines, running memory of complicated task queues (only a couple of which really concern the terminal or system), and all manner of articulation work performed invisibly by the user.

Schmidt and Simone (1996) show that production/coordination work and articulation work (the second set of invisible tasks previously described) are recursively related in the work situation. Only by describing *both* the production task and the hidden tasks of articulation, together and recursively, can we come up with a good analysis of why some systems work and others do not. The magnification we encountered in our studies of users concerns the disruption of the users' articulation work. This system is necessarily fragile (as it is in real time), depending on local and situated contingencies, and requires a great deal of street smarts to pull off. Small disruptions in the articulating processes may ramify throughout the workflow of the user, causing the seemingly small anomaly or extra gesture to have a far greater impact than a rational user-meets-terminal model would suggest.

THE THORNY PROBLEM OF INDICATORS

One of the difficulties in studying infrastructure is distinguishing different levels of reference in one's subject matter. This is a difficulty shared by all interpretive studies of media. For instance, suppose one wishes to understand the relationship of scientific advertising to cultural values about science. At one level of reference, one could count the frequency of ads, their claimed links with sales, and the attendant budget without even reading a single ad. In this case, the ads are indicators of resources spent promoting scientific products. Taking a step into the content of the advertisements, one could trace the emphases placed on certain types of activity, or the gender-stereotyped behavior embodied in them, or what sorts of images and aesthetics are used to display success. Here, one is required to assess the stylistics of the advertisements' creators—including ironic usage, multiple levels of meaning, psychological strategies employed, and thus their meanings. Finally, one could simply take the advertisements as a literal transcript about the process and progress of science, to be read directly for their claims, as indicators of scientific activity. To generalize this, one can read information infrastructure either as:

- a material *artifact* constructed by people, with physical properties and pragmatic properties in its effects on human organization. The truth status of the content of the information is not relevant in this perspective, only its impact; or as
- a *trace* or *record* of activities. Here, the information and its status become much more relevant, if the infrastructure itself becomes an information-collecting device. Transaction logs, e-mail records, as well as reading things like classification systems for evidence of cultural values, conflicts, or other decisions taken in construction fall into this category. The information infrastructure here sits (often

uneasily) somewhere between research assistant to the investigator and found cultural artifact. The information must still be analyzed, and placed in a larger framework of activities; or as

- a veridical representation of the world. Here, the information system is taken unproblematically as a mirror of actions in the world, and often tacitly, as a complete enough record of those actions. Where Usenet groups' interactions replace fieldnotes entirely in the analysis of a particular social world, for example, one has this sort of substitution.

These three sorts of representations are not mutually exclusive, of course. There is, however, an important methodological point to be made about where one's analysis is located. I have several times advised student theses that elide these functions of indicators, and it is a difficult and painful process to disentangle them. Films about rape may say a great deal about a given culture's acceptance of sexual violence, but they are not the same thing as police statistics about rape, nor the same as phenomenological investigations of the experience of being raped. Films are made by filmmakers who work within an industry, constrained by budgets, conventions, and their imaginations. Similarly, as an example from information infrastructure, people send e-mail according to certain conventions and within certain genres (Yates & Orlikowski, 1992). The relationship between e-mail and the larger sphere of lived activity cannot be presumed, but must be investigated.

The processes of discovering the status of indicators are complex. This is partly due to our own elisions as researchers, and partly due to sleights of hand undertaken by those creating them. A common example is the substitution of precision for validity in the creation of a system of indicators or categories. When large epistemological stakes are at issue in the development of a system, one political tactic is to focus away from the larger question, and instead to seize control of the indicators. Kirk and Kutchins (1992), in their study of the DSM, show precisely this set of tactics at work between psychoanalysts and biologically-oriented psychiatrists in the construction of that category system. Rather than (as they had in fact been doing for years) focus on the larger questions of mind and psychopathology, the designers of the DSM reframed the indicators, including how to frame requests for reimbursement from third parties, into a set of numbers that gradually squeezed out psychoanalytic approaches. I noted a similar set of activities by brain researchers at the turn of the century (Star, 1989).

BRIDGES AND BARRIERS

At least since Winner's (1986) classic chapter, "Do Artifacts Have Politics?" the question of whether and how values are inscribed into technical systems has been a live one in the communities studying technology and its design. Winner used the example of Robert Moses, a city planner in New York, who made a

behind-the-scenes policy decision to make the automobile bridges over the Grand Central Parkway low in height. The reason? The bridges would then be too low for public transport—buses—to pass under them. The result? Poor people would be effectively barred from the richer Long Island suburbs, not by policy, but by design.

Whether or not one takes the Moses example at face value (and it has been a controversial one), the example is an instructive one. There are millions of tiny bridges built into large-scale information infrastructures, and millions of (literal and metaphoric) public buses that cannot pass through them. The example of computers given to inner-city schools and the developing world is an infamous one. The computers may work fine, but the electricity is dirty or lacking. Old floppy disks do not fit new drives, and new disks are expensive. Local phone calls are not always free. New browsers are faster, but more memory hungry. And one of those now popular will not support the most popular Web browser for blind people in text-only format.

In information infrastructure, every conceivable form of variation in practice, culture, and norm is inscribed at the deepest levels of design. Some are malleable, changeable, and programmable—if you have the knowledge, time, and other resources to do so. Others—such as a fixed-choice category set—present barriers to users that may only be changed by a full-scale social movement. Consider the example of choice of race in the U.S. Census forms. In the year 2000, for the first time, people may check more than one racial category. This simple infrastructural change took a march on Washington, years of political activism, and will cost billions of dollars. It is opposed by many progressive social justice groups, on the grounds that although it is biologically correct to say that most of us are multiracial, the effects of discrimination will be lost in the count by those who claim multiple racial origins.

Applying the insights, methods, and perspectives of ethnography to this class of issues is a terrifying and delightful challenge for what some would call the information age. The effort to date has linked historians, sociologists, anthropologists, philosophers, literary theorists, and computer scientists. The methodological side of the questions posed is underdeveloped by contrast with the power of the findings of this "invisible college." Thus, the articles in this issue are a most welcome addition to a literature of growing importance.

NOTES

1. I am grateful to Kevin Powell for this point. This modularity is formally similar to Hewitt's (1986) open systems properties (see also Star, 1989).

2. At least, that is, when those thousands are heterogeneous, distributed over many sites, and perhaps anonymous. Becker (personal communication, February 25, 1999) points out that some ethnographies of thousands have been done in large organizations (see, e.g., Becker, Geer, & Hughes, 1968).

3. This title is stolen from Becker's (1998) invaluable *Tricks of the Trade*, a handbook for conducting good social science research. The stealing, of course, is one of the key tricks of the trade. To quote Latour (1987), "les deux mamelles de la science sont peage et bricolage" (the twin teats of science are petty theft and bricolage).

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