HOW TECHNICAL IS TECHNOLOGY RESEARCH?

Acquiring and Deploying Technical Knowledge in Social Research Projects

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As our five-hour trip entered its eighth hour, we were driving through a Midwestern blizzard on Interstate 94. I had borrowed a university motor pool subcompact that wasn't up to the job, and it slithered through the whiteout with the wipers on high, packed with jiggling cameras, microphones, laptops, and a solid-state recorder. My job was to drive, or at least to try to maintain some forward progress through the snow. My colleague was trying to call our next interview, who had agreed to find us a place to sleep. The cell phone alternated between no signal and no answer. It was late at night, and there was no other traffic.

I had my first government grant and a great sense of responsibility. Everything seemed to be riding on these visits. I arranged a three-state driving tour during Thanksgiving break to interview the most promising members of my sample: groups that build their own alternative communication systems. I was then following sixty groups, and the plan was to select the few that seemed to have produced something truly significant and were near enough to reach by car. We would visit them for a day to tour and photograph what they had built, and we would get them to explain how they did it. Thanks to my own overambitious timetable, we had high expectations, we were pressed for time, and we were short of money.

The next morning, in the bright calm after the storm had passed, we walked through a downtrodden residential neighborhood in parkas and snow boots, taking pictures and recording everything: the community center, the park, the condemned house, the abandoned car, and the wireless antennas. Our hosts worked in a local nongovernmental social services agency, and they knew just what we wanted. No doubt they had been called upon to give this tour many times—certainly a representative from each of their various funders would have wanted one. Looking back on the interview transcripts, I see now that they knew just how to package their work for our research: the tour leader had a doctorate, and in fact everyone in our party had a graduate degree.

The person I will call Dr. Gunn led the party, and he explained all of the good the project had produced. In short, they had built their own wireless communication system for the community, and it had made a difference. But in addition to broad statements about educational opportunity, new jobs, and better quality of life, he also had vivid anecdotes of success. Better still, his stories were fresh, and his technical approach was unusual. If it worked here, it looked well worth replicating elsewhere. It was everything I hoped to write about. I was excited.

Gunn didn't concern himself with the technical aspects, so he turned us over to Veronica, who held a graduate degree in information systems engineering. Information technology infrastructure itself is not usually much to look at—it is typically just a bunch of beige boxes. Nonetheless, I still asked to see parts of the communication network in operation. After some initial ambivalence, Veronica agreed. She led us up ladders, through crawl spaces, and across rooftops to show us how the network functioned. Then it happened: the moment when it all unraveled.

On the top floor of the community center that controlled the wireless system, we walked through a utility closet to get to the roof, passing by a communications patch panel. This was a CAT5 patch panel for telephone and Ethernet, and it looked like they all do: a jumble of color-coded wires and blinking LEDs. We stopped in the corridor for a moment to position the ladder and to try to get the heavy roof hatch open. Since we had stopped, I asked a technical question about how the signal for their network traversed the panel—my question was at the outer limit of my own technical expertise. After I heard Veronica's response, I looked more closely at the panel and noticed that what seemed to be the appropriate section of the rack had no lit LEDs. I asked her about it. She came back to the panel, opened the clear plastic cover, and looked at the racks more closely; then she became more and more nervous. She fished out one prominently dangling black patch cable and plugged it into a port. Soon the dark section was a sea of twinkling green LEDs, just like the rest.

THE PATCH PANEL: THE VALUE OF TECHNICAL KNOWLEDGE

Without a little technical knowledge, this moment has little significance. But what I knew about the technology made me jump. I quickly thought to myself, "How long has that cable been unplugged?" "Why didn't the users complain?" "Why didn't anyone who works here notice before I did?" "What kind of network is unplugged without anyone noticing?" I had to admit that the answer to the last question was, "one that doesn't get much use." That patch panel was the turning point for the visit. The project we were excited about existed only as an idea.

Through careful questioning, we eventually unraveled all of the initial claims that had been made about the project. We had thought it was a project for 200 homes. Then we thought that this was a pilot project for 20 homes that would provide expertise for a larger project with 200 homes. Then it turned out that 20 homes was the "recruiting goal." While the point of the project was to provide Internet access for people who would not otherwise have access to it, all of the users already had access to the Internet through some other means. The few people who had signed up had also quickly dropped out, even though participation was free. After another hour of talking, a team member finally admitted that the elaborate community-wide wireless system currently served just one house. (And that house, apparently, didn't use it enough to complain when the network was unplugged, so no one had noticed that the network was shut off.)

As I reflect on that visit, I feel sure that I would have come away from that project site with a dramatically different view if I hadn't looked carefully at that patch panel. The question I asked about the patch panel owed a big debt to serendipity, to be sure. I don't know what made me think to ask about it, and if I had come on another day the uplink cable might not have been unplugged. Beyond chance, I was also able to ask about it because I knew what a "patch panel" was, I knew how to read the LEDs on one, and I knew just enough about network engineering to be able to ask a network engineer comprehensible questions about routing and backhaul distribution to a wireless network.

This technical knowledge saved me from quite a bit of professional embarrassment. Let me say that Dr. Gunn and Veronica weren't liars; they were very careful that their statements were *factually* true. They were in the business of helping people in a neighborhood that needed a lot of help, and this high moral ground and their own enthusiasm for the project probably led them to present the best possible picture to researchers. They knew that if I produced any peer-reviewed research that cited them as a success story, they could almost certainly convert this citation into more grant money for the project. This "success story" case study is plausibly the article I would have written. By saying this, I don't mean to suggest that Gunn and Veronica are special or corrupt in any way but simply to highlight the transaction that is always in play whenever a social scientist is writing about grant-funded public interest projects, or lending her name to what is sometimes called "evaluation research."

Through careful questions, multiple interviews, and long-term engagement with their project, I may have been able to find out some of what I know now without knowing about the patch panel. Maybe a user (or is it "the" user?) would have sought me out and whispered, "this thing doesn't work for s——t," as happened when I visited a different project on this same tour. Yet the patch panel moment still seems important. By knowing the architecture of their specific network and knowing about the significance of a pattern of lights on a piece of hardware, I knew a crucial thing about their project that they would not have told me. Namely, I knew that it was turned off. This situation led to a whole series of questions that otherwise would not have been raised.

In this chapter I want to discuss that technical knowledge and how I came to acquire it. As a social researcher studying technology without a technical degree, I have spent a long time worrying about technical knowledge. When I was a graduate student, I often feared that I would be unmasked by my interlocutors or colleagues as a fraud. I feared the question that a relative recently asked a friend of mine at a family reunion: "That's what you do? But what do you really know about technology?" (My friend was a social researcher.)

NEW TECHNOLOGIES AND NEW RESEARCH PROBLEMS

Although the research project just described in the introduction was based on the qualitative methods of open-ended interview and ethnographic participant observation (Dr. Gunn's field site was based on interviews only), the issue of technical knowledge is consequential for researchers studying technology using any method. It is easy to believe that a survey researcher writing a questionnaire to measure computer skills would do a better job if the researcher was very skilled at using computers. It seems plausible that an econometric analysis of firm behavior in the semiconductor industry would be better if its authors knew a lot about how semiconductors are produced.

My own research is about communication technology, and it is multidisciplinary, bridging the areas of law, communication, and science and technology studies (STS). But any researcher who has considered a technology-related project has encountered some form of "the technology problem" that I address in this chapter. My colleagues in communication, sociology, economics, anthropology, political science, and other fields have conducted their own research studies about online communities, e-commerce, blogging, and cellular telephones, and I wager that they have also wondered about the role of technology in these essays.

There is one particular area of scholarship specifically directed to the social scientific study of technology—sometimes called "technology studies"—and it developed from the flowering of science and technology studies in the 1980s (for a review and introduction, see MacKenzie and Wajcman 1999).[1] In addition, there are increasing numbers of studies of technology in all sorts of fields. Some of these are motivated by new developments in information technology (e.g., for a review of the Internet's consequences for several fields of scholarship, see Nissenbaum and Price 2003). The social sciences are awash in what Lewis Mumford and Patrick Geddes have called *technics*.

Despite all of this work on technology, when I was a graduate student I didn't know how to proceed when I wanted to start studying a technological area. If I wanted to write a social science dissertation about the Internet (my first attempt at a topic), how much did I need to know about how the Internet works? I wondered, "Do I need to be able to program my own Web browser or just know how to use one?"

It is true that the problem of acquiring specialist knowledge applies to any researcher: research itself could be defined as the acquisition of specialist knowledge. Any successful dissertation or research project involves finding out a lot about a very narrow topic, not just a study of technology. Yet studying technology has always seemed to me to present unique problems beyond research generally. I will focus on two problems that have always bothered me.

First, all of research is filled with what linguist and sociologist Basil Bernstein has called "restricted codes"—speech that is "played out against a background of assumptions common to the speakers" (1964, 60). I know it is part of my job as a researcher to learn to get inside these codes that are relevant for my chosen topic. But technology jargon, unlike the vernacular of a street gang, is often elaborated somewhere.[2] That is, you can look it up in places like technical reference books and Web sites. Indeed, there may already be university courses about it. This has always presented me with a time management problem. As a beginning social researcher who wanted to study technology, I often wondered if I should really be taking courses in engineering instead. "Maybe I'm in the wrong degree program," I worried.

Second, studying new technology can feel very risky. Certainly good research usually feels risky (see Richards 1986), but because little is presumably known about new technology, it is often hard to say which technological features will have lasting importance. It can be quite difficult to know what to do with technical knowledge even if you have a sufficient amount of it, as it separates you from other researchers in your field unless they happen to be studying your particular technology. This problem is more acute in studies of new technology than for other areas of research. For instance, the popular currency of new and controversial developments in technology (e.g., see Lightman, Sarewitz, and Desser 2003) routinely propels graduate students to begin projects that may be beyond the experience of their advisers or dissertation committee members. Yet if you succeed at a risky study of a cutting-edge technology, you can reap great rewards. While I was a student, I asked a faculty member to advise my undergraduate thesis, and he asked me skeptically in response, "Why do you think this [sarcastic tone] '*World Wide Web*' is so important?" (It was a question I did not answer to his satisfaction. Ultimately, he declined to advise my thesis.)

I do not have the solution to these problems, and to some degree they continue to trouble me. Still, I am going to use this opportunity to present some of my research experiences and my own particular responses to the problem of technical knowledge. My first step has been to recognize that everyone working in a technical area has these kinds of problems.

KNOWLEDGE "IN SOME CASES SUPERIOR"

As a student, I read fantastic scholarly books about technology like Thomas P. Hughes's history *Networks of Power*. These were inspiring, but like book-length scholarship in many research literatures, they often gave no clue as to their methods. To solve my confusion, I turned to reading about research methods (like this book), but I often found formal methods handbooks to be terrifying. For instance, the qualitative methods literature sets a very high standard for what sort of domain-specific knowledge a social researcher ought to have when studying a technical topic. Methods textbooks straightforwardly direct that "good ethnography" in the area of technology requires that "the ethnographer develops near native competence in the technical aspects of the science and technology involved" (Hess 2001, 239). *The Sage Handbook of Ethnography* states:

> The standard of near native competence does not mean that one necessarily could pass, for example, a general doctoral exam that covers a wide variety of subfields in, for example, biology. Rather, the technical competence of the fieldworker tends to be narrow band—limited to specific subfields—where one's control of the literature is equivalent to that of the experts, and in some cases, superior to it. . . . This is a high standard that often requires years of research. (239)

It doesn't seem like the social researcher is getting away with much! I imagine few students perusing the *Handbook* before their fieldwork are very relieved to find that they should "only" aim to best their informants in *some* technical and scientific areas, and not in all of them.

The need for this domain-specific knowledge is also scary because it isn't clear exactly how you should go about acquiring it. I never know how much time in a given research project should be devoted to learning domain-specific technical knowledge. When I spend time reviewing the literature, I am not sure if I should be reading the trade and technical literature or reading more in the social science and theory about related technologies (themselves often quite technical). Any one choice could absorb all of the time I have available.

I found my first great source of relief from these worries when I discovered that some authors admit that they have these problems, too. A variety of these experiences can be found in nooks and crannies of the anthropology of technology, and science and technology studies literature, for instance. Writing about himself, Collins candidly admits that

> [he] has some thirteen hours of tape recorded interviews . . . on a theory of amorphous semi-conductors which he is quite certain he does not

> understand, in spite of the knowledge of technical terms and acquaintanceship with the literature which were developed over a long period of interaction. (Collins and Pinch 1982, 21)

Similarly, in the classic *Laboratory Life*, Latour and Woolgar (anthropologist and sociologist) describe the experience of trying to read articles in a related technical journal while performing an ethnographic study of a lab. They wrote: "Many of the terms were recognisable . . . the grammar and the basic structure of sentences was not dissimilar to those he used himself. But he felt unable to grasp the 'meaning' of these papers" (Latour and Woolgar 1986, 75).[3]

In Woolgar's phrase, "the fact that all our analyses are essentially flawed is better celebrated than concealed" (1982, 494). In my own research, I have not usually had the space to elaborate at great length on my methods and their failings. In the area of communications technology and policy, personal reflection or autoethnography is discouraged. But my point here is that even those who do not belong to a school of writing that allows you to admit these moments of confusion are likely to find that it helps a great deal to read others who can.

CREDENTIALING SOCIAL RESEARCHERS IN TECHNICAL TOPICS

Clearly one important goal for a researcher starting out in a technology study is to be sure that the results are not wrong because of some sort of technological misperception. One response to this problem of technical ignorance is to study up before you begin. Attaining the appropriate extra degrees and credentials when you do technical work has always been an attractive solution to me because I sometimes hope that some additional credential would put to rest a nagging impostor syndrome. (As I commented previously, I have always feared the question, "but what do you really know about technology?")

Whenever I considered getting extra degrees and credentials, I would daydream heated academic conference debates that would end with me saying something like, "well, I *do* have a master's degree in computer science!" or "well, in fact I *am* a member of the federal bar."[4]

I never got those credentials, and I now see that those daydreams just are not very plausible. While a technical degree can give you an entry into a professional community or a restricted code, heated debates are not concluded by stating credentials. I will not rule out technical credentials as a strategy, but my own experience shows some of the difficulties with them.

My work is multidisciplinary. My research on Dr. Gunn and others like him is grounded in three fields: (1) communication, (2) law, and (3) science and technology studies. Working in and across these three specific disciplines has made it plain to me that a great miscellany of educational approaches has evolved in the subfields that study technology. Many of these approaches are premised on strange and unworkable assumptions.

Take the study of law as an example. Lawyers, as a group, are enamored of credentials—it is a crime to impersonate an attorney. While there are many technological areas in the law, the area of intellectual property is perceived to be the most technical, and within intellectual property law, patent work is the pinnacle. To work in intellectual property law, a bachelor's degree in any scientific or technical subject is recommended, and some bar association newsletters and career guides suggest that the aspiring lawyer consult the list of approved degrees issued by the patent office.

Even though the list of degrees is intended by the patent office to represent fields that produce patents, the law profession uses the designation in a more general way to suggest technical credentials to anyone interested in intellectual property law (see U.S. Patent and Trademark Office 2004, for the list). That means that in vernacular legal education, students are thought to acquire something in a scientific bachelor's degree that will transfer to any other scientific or technical field. If a student follows the patent office guideline, then the BS in integrative biology specializing in applied animal behavior, the BS in materials science specializing in ceramics engineering, and the BS in physics all essentially serve the same function—to qualify them to think about intellectual property. If their résumés are any guide, intellectual property lawyers often do not work in technical areas that have to do with their technical credentials.

The patent office list wears its science and technology politics on its sleeve, noting that "the following typify courses that are not accepted as demonstrating the necessary scientific and technical training: anthropology . . . behavioral science courses such as psychology and sociology, . . . courses relating technology to politics or policy" (U.S. Patent and Trademark Office 2004, 6). So, for the field of law, while botany and computer engineering both convey a kind of transferable technical-ness, social science does not. This means that of my three-part multidisciplinary research, the legal answer to my question would be that I should absolutely obtain a technical or scientific master's degree before working on technology topics.

Another discipline I identify with is science and technology studies, and technical qualifications have made their way into technology studies programs as well. For example, some undergraduate and graduate programs in STS have a "technical depth" requirement. One BS in Science and Technology Studies requires 8 courses in philosophical, social scientific, and historical perspective and 12 courses in science, engineering, and mathematics, while another BS can only be pursued as a second degree program with a science or engineering major.[5] Although there are few graduate programs in STS, they often encourage earlier degrees in a science and technology related major. Increasingly, the STS answer to my question is then probably that I should get a technical degree.[6]

Other fields have never embraced technical credentialing. My PhD is in communication. A communication researcher (or a sociologist, anthropologist, or economist) studying technology at any level is unlikely to find any technical coursework requirement, even within a declared emphasis like "sociology of technology" or "communication technology."

This situation can lead to paralyzing anxiety for new researchers. It is unlikely to be clear if technical preparation is necessary, or even what ought to be studied. Academic research is a world that revolves around the formal diploma, yet even with a scientific or technical credential in hand a social researcher is likely to still feel inferior when participating in a technical debate or studying a well-educated community of technically trained informants. Even after securing important background knowledge, respect will still go missing. Telling a PhD in a scientific field that you have a BS in that field might get you somewhere, but not to parity.

Although two of my three multidisciplinary homes encourage credentialing, I have found instead that strategic ignorance is far more useful in my own work. That is, I have been happy to be an outsider, and even though this means I make technological mistakes, I use them to learn. While time should be spent studying up on the technical, there is no guarantee that technical knowledge gained in advance will be of much help later. That is why I try to learn all I can about the technology I am studying from my informants. I am wary of technical degrees because they seem unlikely to address my specific research interest or motivation. Using studies of patents, industrial economists once estimated that every year from 5 to 15 percent of all recently acquired technical knowledge that seemed valuable will never be used again (Bosworth 1978). In my own area, communication technology, consultants tell CEOs that they should estimate the useful lifespan of any particular technological skill as two years (Varma 2005).

UNDERPREPARED AND INSECURE

I don't have any technical or scientific degrees. I have always had an interest in computers, and I taught myself how to program them, with some help from my father and my college roommates. I later became good enough at it to work as a programmer, but this is the extent of my technical experience. When I started my first large research project after my dissertation it was to be about nontraditional and "grassroots" communication infrastructure. I was fairly sure that my practical experience with computers would help me, but I was wrong.

Like the *Handbook* quoted earlier, the methodological essays that focus on my own subfield of interest (communication technology and infrastructure) have sometimes urged academic researchers to be just like engineers: to build their own computer networks or to at least enter into detailed technical conversations with system designers that aim to shape technical characteristics of computer networks (Harrison and Stephen 1999, 237). Half of my dissertation committee was technically credentialed in some way, and a few prominent social scientists in my area of technology research (communication technology and public policy) are technically credentialed as well.[7] The main result of this background was that when I spoke to my interlocutors during fieldwork, I often felt unprepared, and I worried that at any moment I might be unmasked as a dilettante or amateur. This happened even when (later on) I knew all about the technical aspects we were discussing.

At first, the more I started to learn about my new chosen research topic, the more worried I became. Undefined acronyms multiplied through my notes like virulent weeds. Since my research was about "wireless computing" and I knew something about computing, I hoped my expertise would be of help, but the subdomain of wireless turned out to have almost nothing to do with computer programming. I could write a computer program, but my discussants sometimes had a background in radio frequency (RF) engineering. The material I came across related to computing was all about routing algorithms and protocols, something that I had no experience with.

I spent some time finding my feet. First, I realized that since I was studying the newest of the new, I needed a way to stay up-to-date on new developments so that I could be a more competent interviewer. I figured this out when one of my interviewees asked me what I thought of a wireless product that had been released just the week before. He referred to it by acronym, and I had no idea what he was talking about. I was surprised to find that he expected me to know what he meant and to have an opinion. I used a news clipping service to solve the first problem. A clipping service now automatically sends a daily list of news stories that contain the technical terms that are of concern to me (later, this service became available for free from Google).[8]

Next, I looked for books that matched my lack of expertise. Although some of the things that I wanted to understand for my research were current general debates in the technical literature of network engineering, I had to work my way up. I started instead by reading how-to guides for practitioners that dealt with specific problems, such as the O'Reilly guides (see Gast 2002).

Finally, I started reading blogs and visiting online communities related to the interests of my participants. Any domain of technology is likely to have an associated blogosphere. This gave me a big benefit over ethnographers from years past: a sampling of the right blogs represents an informal version of an elite technical discourse, but they are written down and relatively easy to obtain. Commentary on blogs doesn't define terms or explain them, but it does tell you what developments in a rapidly changing field of endeavor are worth paying attention to.

All of this discussion has been about preparation, but what is to be done at the specific moment in the field when your interlocutor says something that you don't understand? Even though it is sometimes painful, I think that humility along with an admission of ignorance is the best route. At first I thought that if I didn't know an acronym or have an opinion on a new technical debate that my interlocutors would lose respect for me. On the contrary, one benefit that social researchers have is that in the transaction that is social research, technological populations are often happy to be studied, and to our interlocutors this demands only that we social researchers know about social science.

Let me explain in more detail. Just as Dr. Gunn wanted to show off his project to make it more likely he would receive grants in the future, even technocrats far outside the evaluation research and grantmaking sphere are often happy to be studied. Aside from Dr. Gunn, I also visited a group of antiestablishment technology activists. This group built their own communication systems in part by stealing from established systems in a variety of ways. Some of them could be quite difficult to work with. For instance, a few of them went only by pseudonyms and refused to be recorded. Some wouldn't sign consent documents with their real name. Even though this group had no hope of ever getting a government grant, having an attached social researcher was valuable to them in a way similar to that of Dr. Gunn. It legitimated the group, and it proved to the members that they were doing something important. In short, they wanted to be studied.

To live up to their expectations, I didn't have to have any technology expertise, I just had to know how to study it. My technologist interviewees certainly didn't expect me to have knowledge "in some cases superior" to them—for if I did, why would I be following them around asking them questions anyway? I also learned to recognize my role and to see that when dealing with technologists, my esteem was a kind of currency I could trade with them. When I speak to research participants working in a technical area, I spend this currency when I act in ways that reassure them that their technical work is important.

THE ADVANTAGES OF IGNORANCE

My lack of preparation became an advantage once I began to treat the technical knowledge embedded in my data analytically. That is, one year into the project I finally figured out that a coherent subset of my respondents were in the same boat that I was in. While people like Veronica and Dr. Gunn may have been way ahead of me in their knowledge of the technological systems I was studying, since we were all working on an area of very new technology, everyone was constantly learning.

Thinking about my own deficits provided a point of entry to interview questions and research about technical skill itself. If as a researcher I want to study the phenomenon of open source software (see Weber 2004), I should ask the question: how do people get to be skilled and accepted participants in open source software?

In new and multidisciplinary areas of technology this can uncover a surprising wealth of new ideas and research directions. To take just one minor example, in the course of one conversation I was stunned to find that all of my interlocutors had the same worries that I did. In the area of wireless communication technology, some technologists that I interviewed were moving from wired communications to wireless, and they constantly felt inadequate. They were worried about that same question, "What do you really know about technology?" Others had experience in radio but felt unprepared in the area of computing. Still others had experience in computing but felt unprepared in radio. Another one wanted to work on the business side of wireless, but he saw his technical degree (instead of an MBA) as a big liability. A programmer wished he could work "closer to the machine" at a different level of abstraction that he did not (yet) understand.[9]

I am far from the first to mine the resource of my own technical ignorance. A number of famous studies of science have used a technically uninformed person as an analytic model to understand what is going on during their fieldwork (see Lynch 1982, 506–9; Latour and Woolgar 1986, 43–90). This is a version of the "anthropological stranger" familiar to any reader of anthropological work. In it, "practical disability is turned to methodological advantage, and it becomes a resource for critically examining the taken-for-granted practices which make up . . . ordinary work" (Lynch 1982, 509).

My learning process was the same as that described in the literature. As one example from science and technology studies states,

> the social researcher . . . entering a new domain initially understands neither the banter nor the technical terms pertaining to some new piece of science being investigated. After a painful period the inferences in others' conversations start to become clear and eventually it becomes possible to begin to join in . . . what were once "interviews" then become "conversations." (Collins 2004, 128)

The important thing about this process for me was the need to stop and question the "taken-for-granted practices." It would be entirely possible to learn all about wireless networks without pausing to reflect on why some things were "normal" and some things were "problems."

Unless technology studies students are instructed to take science and technology classes with an outsider's mentality, requiring credentials or coursework from them is depriving them of this experience. In a technical project, "being able to claim prior membership in the field can open many doors, but not without also adding special burdens. . . . the question of positioning sometimes shifts from figuring out how to get in to figuring out how to get out" (Downey and Dumit 1997, 28).

To return to one of the fields that most evokes debate about the value of technical knowledge, let us again consider science and technology studies. While some scholars in science studies are scientists and some are not, Collins writes, "practicing scientists are not, in virtue of their scientific knowledge, noticeably better sociologists of their respective domains than those who have not practiced the science" (2004, 128).

If sociologist scientists are not "noticeably better" than nonscientists in science studies, this begs the question of what role, exactly, technical knowledge plays in carrying out a social research project on a technology-related topic. Rather than "knowledge" and getting enough of it, the crucial thing seems to be what Downey and Dumit (1997) above called "positioning." Successful scholars of technical topics may or may not be technically trained, but they all need to know how to identify the audience for their research and learn to position themselves with respect to this audience. In the social sciences, this is an audience of social researchers. In every study of technology I have to get "inside" or "close" enough to have some connection to the new artifacts and practices that I want to study, be they blogs, wireless systems, or software. But to succeed I have to learn about the technology while still staying far enough "outside" to write articles that appeal to social researchers. To further explain this idea of positioning yourself with respect to your audience, I will consider what it is that audiences want out of new technology research.

POSITIONING: ". . . NOW THIS IS WHAT YOU SHOULD TELL THE GOVERNMENT . . ."

The word *technology* used to be interchangeable with the phrase *the useful arts* (Cowan 1997, 204). I always wanted to study technology topics in my own research because I wanted my work to be useful. There are many ways that this can happen in as many kinds of scholarship. If my findings helped anyone think interesting thoughts about my topic, that would be useful and I would be satisfied. Yet the study of new technology itself adds a pressure to be useful that nontechnological research projects do not share. It is not just that I want my research to matter to someone, but also that if I am studying technology—especially *new* technology—it is a safe bet that many audiences will expect a kind of usefulness that I cannot offer them. I will try to explain what I mean here by using another situation in my own research as an example.

As mentioned earlier, Dr. Gunn and Veronica needed my research because a favorable peer-reviewed article could be converted by them into more funding for their project. That kind of possible transaction is one way that research can be useful. In addition, in social scientific studies of technology most readers relate to the technics under discussion in a number of important ways that differ from other kinds of claims to usefulness.

For studies of widespread consumer products, in the simplest case there is the relation of the reader as user of the technology. As a graduate student, when I first presented some of my research findings about wireless communication at academic conferences, some of the responses I frequently received included "I don't do that" or "My wireless network doesn't work that way." The first response is common to all social research.[10] But the second response is telling.

People look to a study of technology to find out how their own technological objects work, as well as how they (or society) work. Ideally, the reader of an article on technology expects or requires some nuggets of technological explanation alongside whatever other goals the research might have. People hearing about my research on wireless networks, I found, often wanted to relate it to their own upcoming technology purchases or their recent problems configuring their own wireless networks.

More important, the ideas and findings presented in social research about an area of technology where little is known have the possibility of affecting that area—this is the "double hermeneutic" framed by Anthony Giddens (1986, 284). For any piece of research, it is hard to foresee whether or not it will end up affecting its object of study. Yet again with technology research, this dynamic means that I am offering a different kind of interaction to my interviewees than I might be in another area of research.

For example, in my study of wireless communication I often told my interviewees that I was studying the law and policy related to wireless. This frequently caused them to divide knowledge into two categories, what was meant for me, and what I was meant to pass along to the domain of law and policy. One interviewee put it succinctly when he said, "The technology works like I just said, but now this is what you should tell the government . . ."

At the time, I found it flattering that anyone would think that the government would listen to me (it did not). However, what I should have realized at that moment was that my interlocutor was looking through me and trying to discern the purpose of my research and to manipulate it. While the previous quote was about policy-related research, when studying the design of technological objects the terrain of the design itself becomes a strange ground for unusual trades and bargains.

Just as the technology users that read my work expected that I be part engineer and explain technology to them in my social research, the engineers I interviewed often tried to use me as a proxy for the user. When I asked them about how something they were building works, they would often reply with a description of how they *wanted* it to work, and not mention how it actually did (or did not). They would assume I was a kind of user or a proxy user. My experience with the patch panel on my visit to Dr. Gunn's project taught me some skepticism, and future interviews taught me more.

RISK AND USEFULNESS: WHAT IS "OFF TOPIC"?

A further example from a study of science will cement this point. Science studies is a useful comparison because science is seen as highly specialized and technical, and to a novice it looks like a hard case for social researchers to crack. But by and large, the scholars in science studies have had a choice as to which scientific topics they want to research. On the one hand they can choose current debates relevant to popular science or science policy, or on the other hand they can choose examples and issues far removed from the personal experience (or interests) of most general readers.

Social studies of science have done an admirable job in both domains, but technology studies usually tend to emphasize the former—the study of well-known or everyday technology that is self-evidently relevant to a large number of people. Invariably when a research project is meaningfully about technology it is also likely that some manifest consequence or feature of the technology motivated the researcher's initial interest.

The classic Latour and Woolgar study *Laboratory Life* investigated a biology laboratory and subsequently wrote about the construction of scientific facts, yet they intentionally selected a "minor episode" (1986, 106) of science to analyze. For example, among other facts, they chose to study the construction of thyrotropin-releasing factor (hormone), or TRF(H), a topic surely far removed from the interests of most readers of this paragraph, much less their paragraphs.

Although I do not know for sure, my guess is that when they attend professional meetings, it is unlikely that their colleagues ever ask questions like "What do you think of TRF(H)?" "Is TRF(H) a valuable industry I should invest in?" or, "How well does Salk run his lab?" If they had been asked those questions, I think they would be right in saying that they were off topic, and that this explanation would be accepted by most reasonable members of the audience. After all, *someone* cares about TRF(H), but not the audience for social studies of science. To them, it serves only as an example of a broader theory about scientific knowledge.

My own technology-related projects have concerned things that a large number of people use or talk about. The popular or manifest understanding of the technology will not go away, and this frequently drags me into uncomfortable epistemological positions. These often revolve around prevailing expectations about technical knowledge.

In the early 2000s, a colleague of mine who studied the Internet parodied the questions she receives at conferences and professional meetings as: "Internet: Good or Bad?" While many others (most notably Winner 1993) have highlighted the moral imperative for scholarship to be engaged with worldly consequences, the problem here is more about the unavoidability of that engagement and how to manage it.

In my own research on wireless, people ask me questions like these all the time: "What do you think of WiMax [a new wireless technology standard]?" "Is wireless broadband a valuable industry I should invest in?" "How well does Dr. Gunn run his project?" When I started out as a researcher, I sometimes got into trouble when I forgot that these questions ought to be more like questions about TRF(H). That is, I should have remembered: Who cares about TRF(H), or about WiMax? They are only examples that are supposed to teach us something about an underlying theory or process.

HYBRIDITY: "WILL MESH NETWORKING ACTUALLY WORK?"

At the beginning of this chapter, I used my encounter with the patch panel to demonstrate the value of technical knowledge in my own work. In this section, I will use my encounter with another technological situation, mesh networking, to demonstrate the harm of technical knowledge, or at least its complexities.

In 2004 I coauthored a conference paper with two of my research participants (Sandvig, Young, and Meinrath 2004). The paper concerned recent developments in wireless Internet routing, which were at the time a matter of extreme excitement among a small group of experts. I presented the paper at a research conference in Washington, DC. The conference is important in this research area, and I felt the stakes were high.

I was happy to coauthor with my interviewees for a number of reasons. First, I liked them. Second, I had been told by the methods textbooks that in this day and age the goal is collaborative participatory research. I do not steal insights from my subjects like a bandit and publish them under my own name. Instead, we work together using participant validation and collaboration to make a difference in the world. It all sounds naive and a little foolish when I type it out here, but those were my motivations. I should also mention that this may have been a way to make up for that still nagging feeling that I still lacked important technical knowledge. If I coauthored with a skilled engineer, maybe I would become more like one, I reasoned at the time.

After I presented my paper to a full audience, the first question I received was, "Will mesh networking actually work?" This question was, for me, dumbfounding, because I knew too much about it and I cared about the answer. Looking back, maybe I should have been able to see this as a question similar to, "TRF(H): good or bad?" where the obvious answer is then, "I'm sorry but that question is not about the topic of this paper."

But because of my well-meaning collaboration, I knew too much for a social researcher. You, dear reader, do not have to care about mesh networking just as you are not expected to care about TRF(H). (Feel free to skip to the end of this paragraph if you do not like jargon.) I knew that the question referred to a style of network routing, and specifically to an ongoing debate in network engineering concerning the likely efficiency of multihop, self-configuring wireless networks. I could tell from the context that the questioner also meant to include some ideas about business models and forms of social organization for mesh networking that were a hot topic at the time. The questioner also surely wanted to know if the networks would scale, because small testbeds were already well established—the real question was one of scale. I think they also wanted to know what routing protocol showed the greatest promise in this context. And the idea, I thought, was not to ask me about a way of meshing that was only good for one kind of networking efficiency. The holy grail for network research at the time was a protocol that would solve the entire problem, not one part of it. This is called a "general solution." I will stop here, but there were more background and further parameters beyond these.

All sorts of colorful episodes from my fieldwork flashed behind my eyes because this question came up all the time among my informants, and it was a topic of much debate. I had recently sought out the advice of a colleague of mine—an esteemed senior professor of network engineering—and asked him about the debate. He had explained to me that in a recently published article he had constructed a mathematical proof that demonstrated that such a network was impossible, but I could not follow the math. A few months earlier, I had a conversation with a very well-respected networking pioneer who had related his attempts to solve these problems in research funded by the Defense Department in the 1970s. He told a vivid story of his attempts to solve the problem by driving panel trucks in groups all around local roads and pretending that they were tanks. (He said that he had never managed to solve it.)

In sum, I had accidentally become a hybrid. I did not know enough to be a technical expert, but I knew too much to stick to my proper place and insist that the question was off topic. This hybridity is dangerous. Too much focus on the technical side and the two paragraphs preceding this one could have gone on for pages—which too many social studies of technology do. They mistake their own aims and turn into technology textbooks, magnifying that portion of their text where they are most likely to make embarrassing mistakes.

CONCLUSION: THE IMPORTANCE AND DIFFICULTY OF EXPERTISE

At the beginning of this chapter, I mentioned that Dr. Gunn and Veronica may have hoped I would produce a positive case study that they would be able to convert into more grant funding. After the previous example of wireless meshing, another kind of transaction that is often not talked about in the practice of research might be clearer: the way that technical knowledge and external credibility are exchanged whenever a technical domain with important consequences is written about by a social researcher.

It is worth again asking the question given in the title of this chapter. How technical is technology research? Or, what is it that a social researcher needs in order to participate in this transaction of expertise? I hope the examples in this chapter have made clear that there are many possible routes to take. To sum up my own strategies, I would first say that thinking seriously and analytically about expertise is a critical step in a technical research project—and not expertise as the researcher's problem but as *everyone's* problem.

This advice is useful even in technology projects that are not about expertise. If you plan to interview political bloggers and investigate their effect on elections, it is worth at least pausing briefly to puzzle about how they learned to blog, and to consider the implications of different paths to blogging and computer skill on outcomes like the form of blog they produce. Obviously all technology studies will not have expertise as the object of their theories and conclusions. But even when expertise is not the quarry I am chasing, I think I have written better interview questions and made more sophisticated analytic points as a result of thinking about technical expertise as an enmeshing system that all of my interlocutors are a part of with me.

Next, I have learned to follow my influences and embrace ignorance—my initial place in this system—as a research strategy. Rather than seeing knowledge about technology as one peak I must conquer on the path to the greater summit of an exemplary social study of technology, I recognize that I am offering my interlocutors a different gift of legitimation and respect. Technical knowledge, on this climb, isn't a set of acronyms and operations I have to memorize by rote, but a system I have to weigh with a critical eye. Not so much, "What does this acronym mean?" as "What does this acronym mean to them?" As I have tried to explain, this has led me to be skeptical of technical credentialing and technical depth requirements for social researchers, even though they are increasingly common in some disciplines.

Even then, all technology researchers must still fear making an elementary technical mistake for which they will be called to the carpet. I have tried to avoid this kind of mistake by remembering my position with respect to the audience for social research. While my readers, if there are any, may hope for technical knowledge in a social research article about technology, it is my role to minimize my own exposition on technological topics, as they usually just are not the point. Yet the process of this kind of research changed me into an uncomfortable hybrid researcher, part techno part social. As a result, it is impossible to avoid having a stake in technical points that would otherwise seem to be off topic.

Finally, it has always helped me to remember that I am far from the first person to be struck by these dilemmas. Returning to Woolgar's quote that "the fact that all our analyses are essentially flawed is better celebrated than concealed" (1982, 494), I have just celebrated some of my own flaws and worries, and I hope this will in turn confirm Woolgar's conclusion—that some research is better as a consequence.

NOTES

This material is based on work supported by the U.S. National Science Foundation under Grant No. 0546409. The author would like to thank Hope Hall, Rayvon Fouché, and Eszter Hargittai for their advice and support.

1. Despite the word's appearance in the title of this chapter, in keeping with this book's focus I wish to avoid an extensive review of the many definitions for *technology.* For a beginning, see McGinn 1978.

2. In addition to restricted codes, Bernstein proposed that there might be a special kind of "elaborated code [that] . . . facilitates relations between objects" and serves to isolate scientific topics from nonscientific speakers (1964, 65; see also 65, n2).

3. Admittedly, this was a study of science and not of technology.

4. That is, qualified to practice law before a federal court in the United States.

5. See http://sts.stanford.edu/BS.html and http://web.mit.edu/sts/students/undergrad/.

6. At least, if you read the curricula in STS as a guide.

7. My own doctoral adviser, François Bar, holds a Diplôme d'Ingénieur Civil. A member of my dissertation committee, Robert E. McGinn (author of McGinn 1990), holds an MS in mathematics. A few prominent scholars in my field have acquired technical credentials. For example, Robin Mansell became a chartered electrical engineer fourteen years after receiving the PhD in communication and long after she turned to technical topics (e.g., Mansell 1993).

8. See http://www.google.com/alerts.

9. The idea of reflecting on expertise has been one of the important preoccupations of science studies scholarship in recent years (see Collins and Evans 2002, 2003; Jasanoff 2003; Rip 2003; Wynne 2003).

10. It is sometimes called the ecological fallacy.

REFERENCES

Bernstein, B. 1964. Elaborated and Restricted Codes: Their Social Origin and Consequences. *American Anthropologist* 66 (6, part 2): 55–69.

Bosworth, D. L. 1978. The Rate of Obsolescence of Technical Knowledge—A Note. *Journal of Industrial Economics* 26 (3): 273–79.

Collins, H. M. 2004. Interactional Expertise as a Third Kind of Knowledge. *Phenomenology and the Cognitive Sciences* 3:125–43.

Collins, H. M., and R. Evans. 2002. The Third Wave of Science Studies: Studies of Expertise and Experience. *Social Studies of Science* 32 (2): 235–96.

Collins, H. M., and R. Evans. 2003. King Canute Meets the Beach Boys: Responses to "The Third Wave." *Social Studies of Science* 33 (3): 435–52.

Collins, H. M., and T. Pinch. 1982. *Frames of Meaning*. London: Routledge.

Cowan, R. S. 1997. *A Social History of American Technology*. London: Oxford University Press.

Downey, G. L., and J. Dumit. 1997. Locating and Intervening. In *Cyborgs and Citadels*, ed. G. L. Downey and J. Dumit, 5–29. Santa Fe, NM: School of American Research Press.

Gast, M. S. 2002. *802.11 Wireless Networks: The Definitive Guide*. Sebastopol, CA: O'Reilly.

Giddens, A. 1986. *The Constitution of Society: Outline of the Theory of Structuration*. Berkeley: University of California Press.

Harrison, T. M., and T. Stephen. 1999. Researching and Creating Community Networks. In *Doing Internet Research: Critical Issues and Methods for Examining the Net*, ed. S. Jones, 221–42. Thousand Oaks, CA: Sage.

Hess, D. J. 2001. Ethnography and the Development of Science and Technology Studies. In *Sage Handbook of Ethnography*, ed. J. Lofland and L. Lofland, 234–45. Thousand Oaks, CA: Sage.

Hughes, T. P. 1993. *Networks of Power: Electrification in Western Society, 1880–1930*. Baltimore, MD: Johns Hopkins University Press.

Jasanoff, S. 2003. Breaking the Waves in Science Studies: Comment on H. M.

Collins and Robert Evans, "The Third Wave of Science Studies." *Social Studies of Science* 33 (3): 389–400.

Latour, B., and S. Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts.* Rev. ed. Princeton: Princeton University Press.

Lightman, A., D. Sarewitz, and C. Desser, eds. 2003. *Living with the Genie: Essays on Technology and the Quest for Human Mastery.* Washington, DC: Island Press.

Lynch, M. 1982. Technical Work and Critical Inquiry: Investigations in a Scientific Laboratory. *Social Studies of Science* 12 (4): 499–534.

MacKenzie, D., and J. Wajcman. 1999. *The Social Shaping of Technology.* 2nd ed. New York: McGraw-Hill.

Mansell, R. 1993. *The New Telecommunications: A Political Economy of Network Evolution.* London: Sage.

McGinn, R. E. 1978. What Is Technology? *Research in Philosophy and Technology* 1 (1): 179–97.

McGinn, R. E. 1990. *Science, Technology, and Society.* New York: Prentice-Hall.

Nissenbaum, H. F., and M. E. Price, eds. 2003. *Academy and the Internet.* New York: Peter Lang.

Richards, P. 1986. Risk. In H. S. Becker, *Writing for Social Scientists: How to Start and Finish Your Thesis, Book, or Article*, 108–20. Chicago: University of Chicago Press.

Rip, A. 2003. Constructing Expertise: In a Third Wave of Science Studies? *Social Studies of Science* 33 (3): 419–34.

Sandvig, C., D. Young, and S. Meinrath. 2004. Hidden Interfaces to "Ownerless" Networks. Paper presented to the 32nd Annual Telecommunications Policy Research Conference (TPRC) on Communication, Information, and Internet Policy, Arlington, VA.

U.S. Patent and Trademark Office. 2004. General Requirements Bulletin for Admission to the Examination for Registration to Practice in Patent Cases before the United States Patent and Trademark Office. Washington, DC: U.S. Patent and Trademark Office. http://www.uspto.gov/web/offices/dcom/gcounsel/oed.htm

Varma, R. 2005. "Aligning Training with Business Goals." *Express Computer*. Mumbai, India.September 19. http://www.expresscomputeronline .com/20050919/technologylife01.shtml

Weber, S. 2004. *The Success of Open Source.* Cambridge: Harvard University Press.

Winner, L. 1993. Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology. *Science, Technology, and Human Values* 18 (3): 362–78.

Woolgar, S. 1982. Laboratory Studies: A Comment on the State of the Art. *Social Studies of Science* 12 (4): 481–98.

Wynne, B. 2003. Seasick on the Third Wave? Subverting the Hegemony of Propositionalism: Response to Collins and Evans (2002). *Social Studies of Science* 33 (3): 401–17.