CHAPTER 12

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RESEARCH-TECHNOLOGY IN HISTORICAL PERSPECTIVE: AN ATTEMPT AT RECONSTRUCTION

The authors of this book have argued that the significance of research-technologies lies in their trans-community positioning or “interstitiality,” in the openness or “genericity” of their devices, and in the provision of standardized languages or “metrologies.” It remains to be seen where research-technology fits in social studies of science and technology, and how the research-technology perspective contributes to a broader understanding of societal dynamics. In this final chapter we will address these issues in turn.

THE PLACE OF RESEARCH-TECHNOLOGY IN SOCIAL STUDIES OF SCIENCE AND TECHNOLOGY

Research-technology is a long-standing configuration of intellectual and artefact production that has until recently largely gone undiscerned. Research-technology is not another configuration in a possibly novel mode of producing scientific knowledge and devices (see, for instance, Etzkowitz and Leydesdorff 1998 [with an Introduction on 197–201]; Gibbons et al. 1994). The existence and operation of research-technology have been masked by a certain insensitivity, in science and technology studies, to the subtleties of boarder-crossings inside science and between science and other social systems. Indeed, some latter-day students of science and technology have responded to increased boarder-crossings by positing a far-reaching erosion of familiar social forms in science. A better understanding of the process may be acquired by looking at boarder-crossing in terms of the divisions of labor and forms of differentiation in the production of science and technology (Shinn 2000).

Post-seventeenth century science and technology can be depicted as taking three different institutional forms: discipline-related science and technology culture, transitory science and technology culture, and transverse science and technology culture. The study of discipline-related science and technology culture has emphasized institutional and professional elements in the growth of scientific knowledge and distinguished between science and engineering. Analyses of transitory science and technology culture maintain the idea of a demarcation between academia and engineering, but at the same time show how practitioners intermittently pass back and forth

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between the two arenas. A study of transverse science and technology culture is congruent with the research-technology perspective. Here, the idea of the institutional boundedness of science and engineering is preserved, but the focus is on situations where back and forth movement is unceasing. It is conceived as a distinct social form in itself, basic both to the maintenance and separateness of disciplinary science and engineering.

Discipline-Related Science and Technology Studies

The history and sociology of science and technology has largely been written in the framework of discipline-related science and technology culture. Innumerable monographs explore the birth, maturity and occasionally the terminal phase of disciplines like astronomy, chemistry, ecology, engineering specialties, phrenology, geology, physics, or micro- and molecular biology (for example, Abir-Am 1993; Gingras 1991; Heilbron and Seidel 1989; Kevles 1978; Lemaine et al. 1976; Mullins 1972; Nye 1993; Rheinberger 1997). The sheer volume of such scholarship is so abundant and omnipresent that inattentive observers of science might erroneously conclude that the history of modern science is principally the history of discipline-related science. In fact, all three science cultures have operated and co-existed for at least two centuries (see, for instance, Pestre 1997). There are sound reasons for the historiographic emphasis on discipline-related science and technology culture. Disciplines are structured around easily identifiable and stable institutions; and disciplines, like most other institutions, produce and leave behind a voluminous paper trail which renders disciplinary analysis more manageable than other forms of analysis. Science disciplines are rooted in the institutions of laboratories, university departments, journals, national and international professional bodies, conferences and congresses, procedures for certifying competence, systems for awarding prizes, formal networks and unofficial connections. Markers like these facilitate the detection and analysis of definite career patterns and categories of scientific production. Moreover, the perceived centrality of institutions in discipline-related science studies has its parallels in the structural analysis of society at large. Connections and congruities between science and society are easily established.

It is in this frame that certain terminologies and notions from non-science realms, such as political and organizational life, have been carried over to probe the world of science. Thus, Richard Whitley’s studies of the social and intellectual organization of a large number of scientific disciplines have borrowed crucial vocabularies and insights from the organizational structures of non-science institutions and extended them to the landscape of science’s discipline-related culture (Whitley 1984). In a similar vein, general historians have often written the history of science as shaped by world historical tides. An example is Eric Hobsbawm’s chapter on “Science” where he elucidates scientific development as the struggle between democratic nations and fascist/communist regimes for supremacy on the world stage (Hobsbawm 1995). Even the classical work of Thomas Kuhn on scientific revolutions may be interpreted as a case in point.

Transitory Science and Technology Studies

Despite their successes, studies of discipline-related cultures have proven deaf to other equally important cultures in science. And yet, an immense amount of science occurs outside the disciplinary matrix. Many careers and much cognition or construction take place in a transitory science and technology culture which is not systematically congruent with orthodox disciplines.

This form of science is not free from the effects of institutional differentiation, but they are dealt with in complex ways which are sometimes overlooked or misunderstood. Intellectual, technical and professional opportunities sometimes arise near the periphery of orthodox fields. In such instances effective research or career-making requires practitioners to step temporarily across the boundaries of their home disciplines, as they seek techniques, data, concepts and colleague cooperation in neighboring specialties. Most of the time, the quest for additional cognitive, material or human resources involves two, or at the most three, disciplines. Practitioner movement consists of a to-and-fro oscillatory pattern. The trajectory remains circumscribed with respect to time and to scale of movement. It is important to note that in transitory science and technology culture practitioners' principal center of identity and action is still disciplinary, even though individuals do traverse fields.

Transitory science and technology cultures subsume two different yet related trajectories. The life and work of Lord Kelvin is emblematic of one pattern. Norton Wise and Crosbie Smith have documented how Kelvin changed from physics to engineering and from engineering back to physics (Wise and Smith 1989; see also the examples of transitory science culture described by Mulkay 1974). As perspectives opened, the man shifted territory. Nevertheless, Kelvin's itinerary remained circumscribed. Moreover, both from the standpoint of the historian and the professional scientist, Kelvin's fundamental allegiance and identity remained discipline-bound, entwined with the orthodox discipline of classical physics.

Alternatively, transitory science and technology culture can lead to the derivation of a new sub-discipline, as in the cases of physical chemistry, biochemistry, biophysics, astrophysics, and geophysics. The list of such creations is long and deeply rooted in the practices of science and technology. In these cases, the oscillatory trajectories of practitioners mentioned above terminate in the establishment of a novel field – a conjunction of two or several established fields. New sub-disciplines are the product of transitory science and technology cultures. In order to understand these cultures and their intellectual/technical achievements, historians and sociologists must concentrate on interfacing and motion.

Yet, to repeat, in these cultures movement and interfacing still tend to be strictly defined and regulated by disciplinary referents. Institutional demarcations and divisions of labor remain paramount, although they are played out in a specific manner. Focus is on career mobility and knowledge fluidity; but both function in a confining and restricted set of institutional coordinates.

Transverse Science and Technology Studies

While in a few respects transitory science and technology cultures resemble transverse cultures, the latter nevertheless represent a distinct mode of production. In transverse science and technology cultures the degrees of freedom and scope of action of practitioners are far greater than in transitory science and technology cultures. For the purpose of our analysis, we will consider research-technology as an exemplar of this last mode of knowledge/artefact production. As documented in chapters 2 and 3 of this book, research-technology reaches back at least one and a half centuries. It then rapidly emerged in Britain, France and the United States. In each of these sites, and during each historical period, it operated alongside the discipline-related and transitory science and technology cultures. The three cultures may in fact be regarded as interdependent and reciprocally enriching one another.

If, as we suggested, transverse science and technology culture, in the guise of research-technology, has been around for a long time, and has often proven important to the growth of scientific knowledge and technology, why then has it been so conspicuously absent from the historiographic palette? Why have historians and sociologists often overlooked its very existence? Part of the answer to this question derives from the fact that participants in transverse science and technology culture are "moving targets."

Research-technology practitioners' association with employers, disciplines and professions is fleeting. The paper trail needed to document their trajectories is thin and fragmentary, making sociological and historical investigation problematic. The difficulty of sound research is exacerbated by the existence of multiple and diverse vehicles for practitioner productions, from conventional scientific publications to patents, confidential reports, exhibits, commercial products, metrological regulations and many others. For scholars whose investigations are rooted in the detection and analysis of stable institutions and sharp divisions of intellectual and material labor, the dealings of transverse culture prove difficult to survey. Similarly, scholars who represent science and technology as seamless technoscience and who ignore gradations of differentiation and divisions of labor, are oblivious to the subtleties and indeed regular structures of research-technology.

Transverse science and technology cultures are characterized by several elements. Practitioners principally draw their identity from projects rather than the disciplines or organizations that they frequent. Yet the perpetuation of well grounded institutions, in the form of academic and technical professions and employers, remains foundational to these cultures. Such defined settings provide necessary inputs for fresh projects in the form of ideas, information and apparatus. They also consume and validate the cognitive/technical products of the participants of transverse cultures. An arena of action in which practitioners are relatively free to shift about constitutes the social and material space wherein novelties may be generated outside the constraints of short-term demands. Two advantages are gained by generalizing research-technology into a separate science and technology culture. First, research-technology's place in the history of science and technology is clarified, as is its historiographical status. Secondly, certain lacunae and contradictions in the operations and representations of discipline-based and transitory science and the relations between them are explained and resolved.

GENERIC INSTRUMENTATION, DIVISIONS OF LABOR AND DIFFERENTIATION

Attempting to summarize and, to a certain extent, to generalize the lessons to be drawn from the case histories in this volume, it seems to us that the process of an ongoing division of labor and differentiation in research-technology takes place in two interacting spaces: on the one hand in a space of design and dis-embedding of generic instruments by research-technologists, and, on the other hand, in a space of re-embedding of generic equipment, again by research-technologists or practitioners outside research-technology. The first type of practices is located deep inside the interstitial arenas while the second type is performed near their peripheries. Depending on the space research-technologists are operating in at a given time, they shift their stance with respect to differentiation and divisions of labor.

The part of research-technology work which directly involves production of templates strongly relies on divisions of labor. At this point, practitioners require distance and indeed protection from end-user demands and pressures in or outside science. This is necessary for the development of fundamental instrument theory and the design of generic equipment. As long as research-technologists focus on core devices, they remain committed to differentiation and divisions of labor.

However, when they deal with practitioners from industry, the state or disciplinary science, a de-emphasis of divisions of labor and differentiation is required to allow them to enter and re-enter these worlds. Such dealings characteristically occur at two moments in research-technology: when practitioners seek project ideas, concepts, and information from potential local users; and when they engage in demonstrating how generic devices could be tailored to particular local uses. Here, transverse mobility depends on temporarily suspending a commitment to divisions of labor constitutive of the targeted professions and organizations.

The bi-directional boundary crossing by research-technologists in turn induces a partial and temporary relinquishing of customary attachments to differentiation and divisions of labor in the arenas they frequent. As practitioners from industry, metrology, academia, or the military engage in the acquisition and tailoring of generic instrumentation, they too tend to lower the barriers. Once acquisition is completed, members of these professional communities again ground their practices in accustomed divisions of labor.

In sum: gradations of reliance on established divisions of labor are played out in the interstitial arenas where the multi-faceted work of research-technology is performed. Practitioners choose either to maintain their "in-between" positions, which provide the necessary space for generic practices, or to move in and out of neighboring science and industrial cultures. They can move between organizations, research projects, or even paradigms when required; they can also structure practice around a generic instrument-based imperative, appealing to principles of divisions of labor and professional differentiation in order to protect their own project. We see this less as a contradiction or paradox than as a case of flexible institutionalization in a field that requires the wearing of many hats. It is research-technologists' response to the complex set of intellectual, material and social relations that emerged as science, technology and the social order at large have expanded in scale and become progressively differentiated.

GENERIC INSTRUMENTATION, RE-EMBEDDING AND COHESION

We can now advance a stronger thesis, namely, that one impact of generic instrumentation is increased social and intellectual cohesion, which runs counter to the ongoing differentiation and fragmentation of science and society. To the extent that research-technology engenders a form of practice-based universality, it acts as an antidote to the effects of centrifugal forces. How is this possible?

To make a generic instrument effective in end-user audiences' own devices, its adoption entails the incorporation of its protocols. Protocols of generic devices are in turn linked to metrologies. Metrologies contribute to both the constitution of protocols and the circulation of devices. Together with protocols, instrument adopters import implicit working concepts, beliefs about why a generic instrument is effective and ideas about what it can and cannot do; and they import explicit vocabularies, images and notational systems.

Successive re-embeddings in different local material contexts and by different groups yield practitioner assurance that the principles of a template apparatus are solid, and that belief in it is well justified. Belief rooted in local experience and testing gradually gains in objectivity. Practices are independently repeated and are multiplied in numerous environments. This is not the objectivity born of pure reason or the *experimentum crucis*. Objectivization is instead built up through collective practice which is structured around effect-producing materials and procedures. Here, objectivization is practical and cumulative.

As a given generic instrument is tailored differently by various audiences to satisfy their demands, it gives rise to specific niche protocols and vocabularies. If this occurs in many places, ensembles of terminologies and procedures based on the most general principles of the generic device emerge in turn, beyond the local vocabularies. Transverse repertories of protocols, held in common by all users, whatever their local application requirements may be, accumulate. It is important to note that the transverse, quasi-universalizing quality of this process is not only a matter of rhetoric and professional power, but is also very much one of material demonstration and concrete practice in multiple arenas.

The universality born of dis-embedding and endless re-embeddings is a universality of varied experience in countless niches, a universality grounded in informed and legitimate practice. *It is practice-based universality*. The weight of trans-personal conviction, experience and proof stemming from practice-based universality adds to the power of conventional disciplinary tests and procedures habitually employed to buttress sweeping generalizations. It is interesting then to consider the research products of transverse science and technology cultures in terms of materials for "pan-validation." In order for the research outcomes of the transverse science and technology cultures to be seen internally as worthy of being sustained, they must resonate with numerous and diversified outside arenas, whether inside or outside of science.

In sum, cross boundary encounters are grounded in the transverse stock of cognitive and material resources coming out of research-technology programs. Communication between institutionally and cognitively differentiated groups of end-users develops. Seen in terms of its consequences, the dis-embedding/re-embedding cycle of research-technology operates as a cohesive force which counter-balances the dispersive propensities of cognitive and professional specialization – a trait characteristic of contemporary science as well as of much modern social and institutional life. Practitioners from disparate disciplinary horizons and from different walks of life can use the shared vocabularies, techniques, imageries, and notional systems of generic instrumentation to cross their respective boundaries. While dis-embedding/re-embedding is not synonymous with full cognitive and professional integration, research-technology nevertheless figures centrally in the cohesion which ultimately sustains much of science as well as many aspects of social existence. In a more speculative vein, we suggest that the vocabularies and images engendered through research-technology actually help contemporary culture achieve a measure of continuity and stability by furnishing a repertory of shared terminology and common experience to which socio-professional groups from different nations and different cultures can refer, and through which they can address one another.

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