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Devices and Educational Change

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> Things are thick with power relations and politics. (Bijker, 2007 p. 115)

This paper examines two cases of device-mediated educational change. One involves a computer-assisted interactive video module that provided a half-hour of instruction for a university course, the other an assistive communication device that proved a supposedly retarded pre-school child to be intelligent. Both were created in the mid-1980s, in sites roughly 30 miles apart.

The interactive video was viewed as a success and won support for its makers; the assistive communication device was rejected and its maker cautioned against repeating such work. Two decades later there are no records or organizational memories of the devices (save those of their makers), but both, I'll argue, were key events in processes of significant organizational transformation.

I have two aims in examining these processes. One is to shed light on the roles of devices in organizational transformations initiated by middle-level workers such as technicians and teachers. I'll argue that device mediated changes, rather than the predefined outcomes of planned efforts, or the products of activity systems organized around explicit objectives, are effects of non-linear processes arising out of improvisations that 'continuously generat[e] new results' (Abbott, 2005a, p. 402) across the worker's career. Devices are key to these improvisations: They shape change by slowing things down (orienting work around devices that don't exist yet and require indefinite development processes), or speeding things up (creating devices that seem to do in a short span what otherwise requires long, complex interaction); they re-shape relations among organizations by enrolling allies, or weaken organizational boundaries by making them vulnerable to formerly excluded claimants. Finally, devices can be used to reorganize agency itself in core organizational activities—shifting the location or attribution of who does what, shifting participants from one actor category to another, or creating new categories of agents. Each of these uses appears in the cases described below.

The second aim of the paper is to develop theoretical tools for analyzing such change processes. Although I draw ideas from several fields, the basic perspective taken derives from actor network theory (ANT), 'a disparate family of material-semiotic tools, sensibilities, and methods of analysis that treats everything in the social and natural worlds as a continuously generated effect of the webs of relations within which they are located' (Law, 2009, p. 141). The next section outlines how I want to engage this perspective.

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Devices and Distribution in Actor Network Theory

ANT tells us that we are what we are by virtue of our associations—the ways 'our' identities, thoughts, and actions are produced and spread through people, things, situations, and structures (Law, 1994, pp. 100–101; cf. Lave, 1988; Hutchins, 1995). The idea is not that there are no differences between people and things, but that they are not and cannot be separated. We can move through different settings, use different artifacts and tools, and interact with other people in myriad ways, but we can't get outside such relations. Detachment and de-contextualization can only be accomplished through re-attachment and re-contextualization. As Munro (1996) puts it, you can only go from one network configuration to another—'one is never traveling out from a place (the core self) and then returning ... the only movement is one of circulation: around and around from figure to figure' (pp. 263–264).

As the term 'actor network' implies, people and networks are thus 'co-extensive' (Callon & Law, 1997, p. 169). Even our thoughts are network effects:

> Parts of our selves extend beyond the skin in every imaginable way ... Our memories are in families and libraries as well as inside our skins; our perceptions are extended and fragmented by technologies of every sort ... . When we use the shorthand 'individual' or 'individual cognition', we are thus only pointing to a *density*. (Star, 1995, pp. 19–20; Latour, 2005, p. 211)

Devices are necessarily central to any account in which 'the social' is thus 'materially heterogeneous' (Callon & Law, 1997, p. 167). What this means is that we have to treat interaction as involving not just physically co-present humans but artifacts and environments which congeal past actions—'new hybrid social-and-material practices are constrained and enabled by equally hybrid preexisting practices' (Law & Singleton, 2000, p. 766)—and mediate the ongoing transactions of people widely separated in time and space. From this perspective, agency, the 'capacity to act and to give meaning to action' (Callon, 2005, p. 4), is not a monopoly of bounded human individuals but instead a 'relational effect' (Law, 1994, p. 100; Callon & Law, 1995, p. 502), possible only by virtue of the fact that people 'hook up' (Latour, 1999, p. 18) with institutions, buildings, landscapes, discourses, artifacts, microbes, and the rest, all of which are also networks or 'assemblages' (Cooper, 1998). 'Action, including its reflexive dimension that produces meaning, takes place in hybrid collectives comprising human beings as well as material and technical devices, texts, etc.' (Callon, 2005, p. 4).

The emphasis in ANT is less on the structure of such hybrids than the movement of their constitutive associations across times and spaces. Networks are treated not as stable structures in static landscapes but as contingent effects of 'translations'—the term ANT practitioners give to the 'displacement, drift, invention, mediation, the creation of a link that did not exist before and that to some degree modifies two elements or agents' (Latour, 1994, p. 32). In some cases translations become relatively stabilized and generate organizational structures, infrastructural categories, and well-defined paths for getting things done. But stability can be difficult to achieve and sustain, and often doesn't take a form foreseen by those who accomplish it.

ANT is less a theory of such processes than a set of assumptions and conceptual tools for studying them. Individually these assumptions are not unique to ANT (e.g. Ingold,

2000, pp. 304–5; Lang, 1993; Hutchins, 1995; Fuchs, 2001), but ANT's ways of formulating and combining them have an entailing incompleteness that pushes us towards empirical engagement. As Law (2009) explains, describing ANT in the abstract 'misses the point because it is not abstract but is grounded in empirical case studies. We can only understand the approach if we have a sense of those case studies and how these work in practice' (p. 141).

At the same time, these case studies should have a heavy theoretical recoil. Each involves a translation of ANT itself, pushing the uses of its tools and methods, challenging its sensibilities. The two cases examined here, for example, raise at least the following questions.

First, *how* are associations among people and things accomplished? There are different ways to 'circulate', 'delegate', 'sum', and 'shift down', and Latour (1996b) acknowledges that ANT 'is an extremely bad tool for differentiating associations. It gives a black and white picture not a colored and contrasted one' (p. 380). A speed bump, to take one of his examples, may be 'full of engineers and chancellors and lawmakers, commingling their wills and their story lines with those of gravel, concrete, paint, and standard calculation' (Latour, 1994, p. 41), but the question is how and why 'commingling' happens—for example, how important to a given outcome is the sequencing of assembly, the pacing of composition, the specific mix of the elements associated, whether a given element is essential to the mix or open to substitution, and whether the associations are reversible or easily changed. Do associations and delegations come slowly and incrementally, allowing different kinds of uses at different stages as a device takes form (or as different versions of a device are produced), or do commitments come together all at once (the organization bets on a particular product)? Are commitments large at the outset or do they gradually build? How does one translation relate to a preceding sequence of translations (e.g., Latour, 1996a, p. 91; Law & Callon, 1992, p. 52)?

Second, if body, agency, and mind are distributed networks, how are they made to look like discrete, bounded entities? It may be true that we commonly 'localize agency as singularity—usually singularity in the form of human bodies', through 'attributions which efface the other entities and relations in the *collectif*, or consign these to a supporting and infrastructural role' (Callon & Law, 1995, pp. 502–503). But ANT does not allow us to naturalize such attributions or take them for granted. We know that people do not always individuate agency in this fashion (e.g. Strauss, 2007; Comaroff & Comaroff, 2001), and the persistence of institutions for producing individual subjects (e.g., Foucault, 1979) and promoting public narratives of 'singularity' (Somers & Block, 2005) suggest that such attributions are unstable and require continuous effort. It is as plausible for people to see cognition and agency as distributed or 'stretched out' across people and things as to think it intra-individual.

Third, terms like 'artifact' and 'non-human' (Barron, 2003) are inclusive by design, but as such deflect attention from questions of who makes (or can make) a certain kind of device, who controls use of the device, how access to it is organized, who supplies the power for it, what kinds of products it makes, how it moves, and how it is made visible to different observers (cf. Kirsch & Mitchell, 2004).

Fourth, ANT's analyses of technological change often bracket focal devices (as I do here)—an aircraft, a self-coupling train car—and treat the networks and translations out

of which they percolate as being about those devices (I try not to). The obvious point is that such processes are often about other things besides or instead of the focal object. The speed bump may not be what the engineers and chancellors were making, but something that was made because or in spite of other things they did. This may not be relevant to an ANT account of 'speed bumps', but it may be what matters to the people involved. If we take 'identity' to mean 'an actor's experience of a category, tie, role, network, or group, coupled with a public representation of that experience ... not private and individual but public and relational' (Tilly, 2002, p. 75), organizations are not only about 'work', 'activity systems'—or devices—but also about people and groups making identities through articulations with devices.

Finally, the individuals ANT takes as points of entry in tracing networks are usually high-status participants—officials, administrators, 'engineers, technicians, and technocrats'—situated in 'their own separate world' (Latour, 1996a, p. vii). ANT foregrounds activity defined from these standpoints rather than, for example, those of mid-level workers doing things administrators might not care about or approve of. The two cases that follow, by contrast, focus on how middle-level workers in organizations thread connections among devices and different fields of action, and how the devices simultaneously reshape the workers' organizational worlds. I argue that in these processes the organizations themselves change—though not necessarily as the narratives attached to the devices imply. As Ferguson (1990) notes in another context, 'it may be that what is most important about a "development" project is not so much what it fails to do but what it does do; it may be that its real importance in the end lies in the "side effects" ' (p. 254; but contrast Hirschman, 1991, pp. 39–42).

Method

The first case examined below, in which a university-based technologist creates an interactive video teaching device, is based on data drawn from a 1997–2004 study of the introduction of computer-mediated instruction at an American research university (Nespor, 2006). That work involved interviews with administrators and professors (the main sources of data used here), interviews with students, documentary analysis, and classroom observation. The discussion of the preschool teacher's creation of an augmentative communication device is drawn from an extensive ethnographic study of special education practices across time (1989–1991, 2005–2008). In particular I use interview materials (from 1989 and 2005) and documentary materials tracing the work of a teacher, B. The paper also draws on B's own dissertation account of this work, written in 1992.[1]

Foregrounding the work of two people has drawbacks. As Pierson (2004, p. 141) notes, using individuals as entry points for analyzing organizational change favors a focus on 'particular kinds of actors—entrepreneurs, "skilled social actors", and "losers" '. Czarniawska (2009) adds that such research easily falls into the fallacy of '*post hoc, ergo propter hoc:* when an institution has been established, people who were involved in establishing it are seen as decisive for its establishment' (pp. 438–439). This paper may be guilty on both counts, but I would argue that these two protagonists deserve the attention not only as the earliest makers and users in their organizations of the kinds of educational

technologies described, but because these early efforts ramified over the decades into major changes in the organizations, and because both had influence well beyond their organizations on the how such devices came to be used by others. Computer-mediated instruction would have come to the university, and assistive communication devices to the public schools, regardless of whether these two particular people had been involved, but without focusing on individuals we have few ways of understanding or even observing change processes structured across biographical and career-length time frames.

Little 'Demos': Technology and Organizational Identity

Teaching in formal educational settings assumes a web of relations linking teachers, students, schools, and content disciplines. Changing teaching involves changing the translations that generate this web. One way to do this is to work on single elements—for example, train better teachers or create better curricular materials. The approach taken in the case below, by contrast, was to use devices to reconfigure the web of relations connecting university teaching to external networks such as professional organizations and technology corporations.

J, the protagonist of this section, played a key role in this effort. He had arrived at the university in 1971, with the job title of 'producer-director', 'to help set up the Instructional Television' (ITV). ITV was undergoing major transitions at the time. It had prospered through the 1950s and 1960s as a way of improving teaching in the public schools (Berkman, 1977), but funding had begun to dry up, and its future role in elementary and secondary education was looking less promising. In early 1970, ITV's major professional organization, the 'Department of Audiovisual Instruction', had broken from its parent organization, the largest national teacher's union, and renamed itself the 'Association for Educational Communications and Technology' (AECT). About the same time it replaced the term 'audio-visual' in its journal titles with 'technology', shifted its focus from compulsory to post-secondary education, and re-wrote its charter to emphasize 'Educational Technology' instead of 'audiovisual communications'. The former was defined as:

> ... a complex, integrated process, involving people, procedures, ideas, devices and organization, for analyzing problems and devising, implementing, evaluating and managing solutions to those problems, involved in all aspects of human learning. (AECT)

This shift in focus faced a substantial hurdle: In universities, professors control curricula and monopolize access to students. In Barley's (1996) terms, people such as producer-directors are confined to subordinate roles as 'technicians'—operators at 'empirical interfaces' (p. 418) of the work process, responsible for translating representations produced by faculty in otherwise transitory forms (for example, lectures) into more stable and standardized products such as video courses. Such work quickly becomes routine: Instead of an 'artisan' involved in 'the design of things', J became an 'operative' to whom 'their construction' was delegated—a provider of standardized solutions to a finite set of puzzles (Ingold, 2000, pp. 295–296; also Braverman, 1974). Looking back from the late 1990s J recalled working with 'hundreds of faculty' and producing 'close to a thousand [television] programs' over a dozen years. But:

> Everything had gotten too formulaic. They came in the door with a problem and I knew 'that's solution 32'—and I'd go make that guy a program. And I knew just about every answer I could think of. So I wanted to do something different.

To do something different he went back to graduate school for a doctorate in Instructional Systems Design. This allowed him to explore innovative uses of instructional technology at other universities:

> ... there was very early experimentation ... People were trying to uncover how to get away from the linearity of television, to introduce interactive control ... I was intrigued with computer assisted instruction (CAI) as a domain ... .

As phrases like 'experimentation' and 'getting away' imply, there was no orthodoxy or standard model of CAI at the time. Neither, J recalled, was there much awareness or interest in it among administrators at his university: 'nothing like that here, nor any funds to buy anything like that'.

To 'do something different', then, he needed to connect his work at the university to innovative efforts elsewhere, forge a coherent organizational identity from those connections, change his relations with faculty members from operative to artisan, and build an institutional base.

The effort took years, and a key episode shaping the path it followed was the production of a device. After obtaining his doctorate, J had moved to an 'instructional developer' position, and began what he recalled as his 'first significant project' in 1983. It was a collaboration with a professor, S, to make a device that would present content (in video form) and link it with student performance (through a computer program). S recalled that J:

> ... sent out a memo around campus ... 'If anybody wants to do interactive video, we've got the resources to make it happen' ... . I'd been reading non-stop in trade publications ... sort of computer nerd stuff, you know ... So ... I'd probably read about interactive video ... . And I thought, 'well, what the heck?'

This recruitment strategy made it likely that volunteers would be 'gadget-scientists' (Nutch, 1996)—professors accustomed to dealing with technical issues 'impinging on their work without relying on outside or standardized resources' (p. 215). With such collaborators, and a focus on CAI, the object of work shifted from video production to software coding, a move allowing J to reconfigure work relations: much of the responsibility for writing code fell to S, who recalled spending '500 hours of time [writing code] to produce half an hour of instruction'. The idea, he explained:

> ... was to videotape some instructional stuff, and create to run parallel to that a program that ran on the Apple IIE ... . And at various points throughout that instruction it would stop and ask a question. For example, if the student got the question right, they would proceed forward according to the software code that I created, and if they got it wrong it would perhaps route them back to some remedial instruction.

Five hundred hours would seem a steep price for 30 minutes of instruction, but instruction wasn't really the focus. Far from transforming teaching and learning, the interactive video project pushed them, and the course itself, out of the frame and centered attention on an idea of 'courseware' embodied by the device. Courseware implies shifts in the location of teaching agency from the instructor to the device, and of design agency from the professor to the instructional technologist—both shifts accomplished through a particular kind of performance, the demonstration. As J explained, such performances constituted the main use of the device:

> We actually used this maybe three or four semesters. Got a whole lot of conference presentations, a couple of articles. Our whole thrust was, 'here's how faculty can get involved in this new kind of way to teach, give students some control over how they learn'.

As S recalled, they traveled around the country:

> ... hauling an APPLE IIE and an APPLE IIE monitor, and a VCR and a big, hopefully a big TV ... and then hooking that all up, and literally demo-ing the ... courseware ... and explaining the how and why and answering questions after it.

Shapin and Schaffer (1985, p. 60) described 17th century scientific illustrations as instruments of 'virtual witnessing'—representations that allowed (or persuaded) dispersed audiences to accept the results of experiments that had been staged in settings distant in time and space. Demonstrations like those of the interactive video, by extension, might be labeled mechanisms for 'witnessing the virtual': They enable audiences to imagine devices that do not exist, by showing them what are said to be precursor artifacts in the hands of people who can supposedly make the real things at a later time. As Barry (1999) notes, 'the idea of the *demo* implies provisionality. A demo model is a display of the possibility of a real object, rather than its actualization. It is a way of showing what can or might be done' (p. 77).

Perhaps as importantly, demonstrations are 'performative' enactments (Law & Singleton, 2000) of possible identity positions for the technology's makers and users. In this case, at least, the demo was a translation device for shifting instructional technologists from operator to artisan positions in the 'standardized package' of methods, technologies, and shared objects through which they and university faculty jointly collaborated to 'construct and solve "doable" problems' (Fujimura, 1992, pp. 176–177). More than this, however, the demo was a device for shifting J's public identity nationally and locally. Recall that an 'identity' consists of a configuration of ties—a particular way of assembling an actor network—coupled to a public narrative. As both an 'autographic' object—'with traceable origins that can be directed attributed to an individual' (J & S), and an 'allographic' object, 'whose origins cannot be traced' (an exemplar of an imagined class of computer-mediated teaching devices) (Bechky, 2003, pp. 741–742; citing Goodman, 1978), the demo was a means of generating a narrative of J and his unit as the local group capable of producing computer mediated teaching (cf. Bechky, 2003, p. 725) *and* as the link connecting the university to a national network of instructional innovation. Indeed, it was one of the mechanisms for creating that national network. If the interactive video

as autographic stayed tethered to J's unit, as allographic it could be combined with other demos into collections, then circulated nationally. J recalled that he:

> ... hooked up with several other people doing similar projects. In a span of three years collected, really people all over the country by then who were doing similar projects. And I collected demonstrations of what they were doing and produced several ... anthologies [of] ... people's work at other universities, for AECT, and they sold these tapes.

Collecting conference demos was one way of assembling allies from around the country into something that began to look like a national movement for computer-mediated instruction. This national presence, in turn, made it easier to get federal grants for new demonstration projects with faculty members, and part of this funding could be used to:

> ... buy a lot of equipment. We built up our internal development base in this department. We used it to hire and train a number of people ... We stepped up from really being kind of backwater and really peripheral, really marginal, to having a resource base at least that some people could use. We went through at least three federal grants in different areas to get to that point.

This accumulation of equipment and personnel would have helped to stabilize an identity for 'instructional technology' (IT) on campus, but making it part of the university's core infrastructure meant translating it into a priority of the entity to which the university was answerable: The state. This required another kind of 'inscription device', specifically a 'Task Force'.

By late 1989 the state in which this university was located, like other states, was dealing with the beginnings of an economic recession. Legislators looking for places to cut budgets found higher education a ripe target (Slaughter, 1993), and part of the university's defense was to construct a narrative of itself as an innovator in the development of more efficient means of instruction that would save money later. Information technologies were key to this narrative—again, as they were at universities across the country—and in the university set up a 'Task Force' on 'The Impact of Digital Technologies on the Classroom Environment' to produce a report that would document its commitment. Although professors made up most of the membership, J was the group's staff person—a role in which he 'gave a number of demonstrations'.

The task force translated these demos into a text—a report which claimed that such technologies could radically transform teaching and learning in the university—that moved differently than the demos themselves. In particular, such texts can be understood as programs or scripts offered to more stable and powerful networks, which are encouraged to quote or hybridize them into new texts that can then circulate through different institutional networks and undergo further translations into budget, policy, and legislative documents.

In this case the uptake was quick. By the time the university task force released its report, the State Department of Higher Education had assembled a 'Governor's Commission' to examine state university policy and suggest directions for its development. For its discussion on the role of technology in higher education, the Commission simply appropriated the report of J's task force as a template, quoting liberally from it and

closely following its argument. Thus re-situated, the language of the task force report was used to justify state higher education funding decisions as late as 1995. We can label this a 'blowback translation', in which the products of a local actor network travel through a translation circuit and return as the actions of another (more global) network, in which form they reshape the premises of local practice. In this case the blowback benefited J's work unit. New Requests for Proposals for education development projects, for example, funneled money to technology demonstrations of the kind already being pursued by J's and his colleagues. Money from these grants then allowed J to enroll more faculty members in his efforts (giving them summer salary money or buying them out of teaching responsibilities), and to hire:

> ... programmers, an artist, it was a CAI [Computer-Assisted Instruction] development lab that was essentially put together ... . Those projects, plus the earlier work with the federal projects, produced some local content that we could trot out on stage to visitors ... the board ... people in the Provost's office, or to Deans. I remember making a lot of demonstrations, little demos.

J's unit also used money from the state grant to organize a dissemination conference for other State-funded IT projects, and J arranged for AECT to hold its summer technology conference at the same place and time:

> So we used state money and invited faculty from all over the state to come free to this thing, and we also pulled in like 100 people from all around the country for three or four days ... . That was a very significant conference.

In the context of budgetary pressures, the collective performances of these national and local projects would have been significant in part because they demonstrated the extent to which computer-mediated instruction had been translated from a risky innovation into a basic institutional commitment, and in part because the presentations would have helped engender a kind of 'professional vision' (Goodwin, 1994): a way of framing and 'coding' teaching so that the audience of administrators and interested faculty would see it from the particular professional perspective of the instructional technologist—as something doable by machine. Such a framing allowed legislators to draw the inference that it might be possible, in the words of one university administrator, to 'capitalize the cost of education'. J and the other technology advocates at the university did not explicitly endorse this idea, but neither did they resist it:

> There are people [at the state level, in the legislature] saying you use technology to save money. We do not answer that directly. We just keep going. Because we were quite certain that you would not save money.

This is not a case of allowing others to delude themselves to your advantage, but more like an offering in a speculative market on instructional derivatives: the translation of some immediate, situated activity in itself not yet or not obviously productive (devices like the interactive video), into a contingent future (a university offering computer-mediated courses), that might in turn be translated into legislative policy (a less expensive university system). One result at the local level was the internal reallocation of university monies to increase support for Educational Technologies. As J recalled, the support flowed:

> ... into us, into this group. And why this group? This group was *the* group that had a long-standing working relationship with faculty on instruction. Not *many* faculty, but we were well perceived as the people, if you had an issue with technology or media or teaching, we were the group you would talk to.

ANT researchers might say that at this point the unit became a kind of 'obligatory passage point' in the university's efforts to promote instructional technology. For Law and Callon (1992), this would be a key point of stabilization. They argue that the success of a 'technological project' depends on whether it can 1) construct 'a global network that will for a time provide resources of various kinds in the expectation of an ultimate return'; 2) construct a 'local network using the resources provided by the global network to ultimately offer a material, economic, cultural, or symbolic return to actors lodged in the global network'; and 3) 'impose itself as an obligatory point of passage between the two networks' (1992, p. 46). In other words, to stabilize themselves, actor networks draw on relatively more stabilized (which usually means more extensive or 'global') circuits for materials, money, or discursive resources. In this instance there were a number of these networks—the computer industry, the AECT, the university system, state legislators, and so on—and multiple 'local' networks as well, including J's technology unit, the university faculty, the administrators, which were in turn already tightly linked to global networks (design fields, academic disciplines, the state university system). A lot of the action thus involves re-articulating local associations among the global networks—redrawing the boundaries of the university, or at least the boundaries of university teaching, to bring it under the partial purview of external networks like those of instructional designers (as much part of the corporate and military sphere as the university)—in ways that don't so much make a particular configuration of associations 'obligatory' as make it predictable and easy to use.

That is, unlike true 'obligatory passage points'—translations that become increasingly costly to reverse over time as more is made to depend on them and other options disappear (Callon, 1991, pp. 149–150; also Pierson, 2004, pp. 20–21)—some identity networks expand and stabilize by organizing themselves through devices and projects easily made and abandoned (cf. Singleton & Michael, 1993). J did not become lastingly identified with a specific device (the instructional video dissipated as soon as its demonstration value dried up). Keeping associations discretionary and reversible, keeping the exact nature of the devices and the extent of their use ambiguous, means that the translation of work and device into financial costs and returns can be largely controlled by developers and backers. It also allows the development process to unfold incrementally, and thus blunts potential resistance from administrators and faculty by allowing them to retain substantial control over timing decisions regarding use and resource commitment. We might call all this a form of 'identity infrastructuring' in which the products of change are not just or even primarily specific devices, or the conduct of a target activity (e.g. teaching), but the relations that create and stabilize institutional actors or identities.

But what if there are no global networks—or only antagonistic ones? What if ties can't be discretionary or loose? What if shifting organizational borders brings in new actors who want control of key organizational decisions? What if a device doesn't change or

improve (or promise to change and improve) existing local practices but changes categories in ways that create problems for other people and entail significant costs? These are some of the questions raised by the second case, but to get to them we have to start with a more fundamental question.

Devices and Change: Tinkering, Cartesian Fixes, Brokerage

How do we know that children who have never spoken, signed, pointed, or controlled their movements enough to use standard communicative devices are capable of the kinds of thoughts, feelings, desires, and rationality we attribute to ourselves? Most Western philosophical perspectives simply assume communicative bodies (e.g. Berg & Akrich, 2004; Merleau-Ponty, 1963; Gallagher, 2005; Grosz, 1994; Shilling, 2005; cf. Moser, 2003). It's understood that people can lose access to embodied abilities they formerly possessed, or be born without certain abilities as normally constituted, but we usually assume they have access to at least some familiar communicative channels, or had access in the past, and thus we read their situations as component breakdowns in intelligent bodies and assume it's possible to communicate with them, or restore communicativeness with appropriate prostheses. To take a famous example, we can trace the physicist Stephen Hawking's biographical trajectory back through amyotrophic lateral sclerosis to a previous embodiment in which he used a full range of communicative channels: thus we assume he remains intelligent and that he can communicate if we provide the right assistance (Stone, 1995; Mialet, 2003).

But how we would know 'Stephen Hawking' were intelligent if he had been born with his late-in-life physical capabilities? He wouldn't be the same 'Stephen Hawking'—his actual present depends on his abled past—but how would we have known that we could communicate with such an embodied person? More generally, how do people *born* with limited or no use of their hands, who cannot move their bodies through the world at will or without the use of 'instruments', become recognizable as intelligent and potentially communicative? How are they made so? It is one thing to say we are all networks, that cognition and communication are intrinsically distributed, but how do we *re-make* such networks for people currently assembled in subordinating or oppressive relations—especially when there are not maps or assembly diagrams available? How do we even convince others that such networks are possible? These were hard questions in the mid-1980s, and B, the person we follow through this section, had to answer them under time pressures from the inside of a preschool classroom.

B had begun teaching at 40, with an English degree and Montessori certification—the latter qualifying her to teach special education in the eyes of the school district. The preschool class she was assigned contained a mix of children, from 'mildly LD [Learning Disabled], a little bit speech impaired, blind and brilliant ... [to] severely mentally and motor impaired'. When the children turned six years old they received official special education labels. Those deemed 'mildly' disabled, a little impaired, or brilliant were sent to regular schools. Those said to have significant cognitive disabilities were sent to a segregated school for the 'severely and profoundly' and 'trainable mentally handicapped'. Children who didn't speak or sign were placed in one of these latter categories. 'One of the ways they could get these people put in the severely

profoundly handicapped classes', B explained, 'is they could say they were untestable' (1989 interview).

School officials considered Michael, the child at the center of the story in this section, one of these 'untestable' students. Diagnosed with 'severe mixed spastic athetoid cerebral palsy', he sometimes moved his head to indicate yes and no, but could not stand, speak, hold objects, or point (B, 1992, p. 224). Officials defined him as severely cognitively impaired. His mother concurred. B, however, came to hold a different view, in part from experiences like the one recounted below.

Following rain one day, B had taken her preschool class outside to the playground, where everyone removed their shoes and splashed in puddles like the characters in the book she was reading to the class, Beatrix Potter's *Jemima Puddle Duck*. The translated embodiments of this event—the children becoming ducklings, turning the book's words and pictures into corporeal experience—also entailed transformations in Michael's bodily incorporation into the class:

> I unstrapped Michael from his chair and held him upright against me as we jumped and splashed. I had seldom heard him laugh so heartily or look so enthusiastic about being a part of things. Because I was holding him upright the way he might be if he could stand, children were holding his hand and relating with eye-to-eye contact at a level he was not used to. (B, 1992, pp. 226–227)

When the rains resumed and B took the children inside for a nap, 'Michael started howling ... He kept looking at the tumbling mat and back to me and making noises louder than I'd ever heard him make' (B, 1992, p. 227). B could have treated these howls as indications of physical discomfort, but instead she took them as what Goffman (1978) called 'response cries':

> Unable to shape the world the way we want to, we displace our manipulation of it to the verbal channel, displaying evidence of our alignment to the on-going events; the display takes the condensed, truncated form of a discretely-articulated non-lexicalized expression. (p. 801)

Reading the howls as protests at the story's interruption, B asked, ' "Do you still want to be Puddle Duck and go to bed?" He nodded and howled in a different way. So I continued as if we were still part of the story' (B, 1992, pp. 226–227). Concluding the book's narrative through this collective performance shifted Michael's status from that of seemingly passive participant to active agent—someone who did the same things as the other kids, and whose expression of will had to be acknowledged by the teacher.

It is impossible, of course, to reconstruct exactly *how* such events convinced B of Michael's intelligence, but the transformation of the physical and narrative organization of the classroom would be part of the answer. Holding Michael changed his bodily orientation to his classmates and allowed B to feel his embodied participation and track his eye gaze in new ways. Making puddles and towels available gave him a non-lexicalized way to participate in the event—participation he extended first through laughter, then 'howls' as the rain initiated a cascade of binaries—outside/inside; story/no-story, laughter/crying,

yes/no—which he could mesh with the ability to move his head and vocalize (cf. Ferm, Ahlsen, & Bjorck-Akesson, 2005, pp. 19–20; Mialet, 2003, pp. 588–589).

Such engagements would have been legible as 'intelligence', however, only because B's extended observations and interactions with Michael and students like him—her experiences of 'managing bodies across private and social spaces' (Kelly, 2005, pp. 190–191; Goldbart & Marshall, 2004, p. 202)—had engendered what Csordas (1993) calls 'somatic modes of attention': 'culturally elaborated ways of attending to and with one's body in surroundings that include the embodied presence of others' (p. 138). As she soon discovered, insights grounded in such relations were not easily reproduced for school officials whose interactions with children like Michael were comparatively brief and superficial, and whose logics of assessment derived from fields like psychology, where as late as the mid-1990s researchers insisted on the 'strong presumptive relationship, in general, between overt production and actual ability' (Jacobson, Mulick & Schwartz, 1995, p. 757).

'Overt production' in this logic did not refer to performances like Michael's in the *Jemima Puddle Duck* story but to 'production' within the spatial and temporal frames of testing events. As Foucault (1979) suggests, a test 'introduces individuality into the field of documentation' (p. 189) and constructs an individual in ways that allow him to be 'be described, judged, measured, compared with others, in his very individuality' (p. 191). In ANT terms tests hide our network-qualities—our histories, resources, tools, and allies—and inscribe us as discrete packages of abilities and potentials defined in terms of measurable categorical essences (e.g. 'intelligence'). One of the perverse entailments of the logic is that the right to be tested becomes a core element of the right to have rights—to be a citizen. To say that Michael was 'untestable' meant that he could not be separated from his associations, and thus lacked measurable essences and 'actual ability'. For administrators this meant he belonged in the segregated school for children with severe disabilities. Nothing B said could change their minds:

> One administrator had patted me on the back and assured me, these children were born limited. 'It's just sad, but it doesn't do to get over-involved'. Another administrator, in a less sympathetic manner, admonished me that I was just going to feed the parents' unrealistic view of what these students were capable of. (B, 1992, pp. 235–6).

To keep Michael out of this school and 'prove his intelligence' (p. 234), then, B decided to figure out a way to test him.

Unlike J, who could redefine teaching as that which his device did (making actual teachers and students unnecessary for the demonstrations), B's problem was to make a device that would be invisible, something administrators could treat, like Stephen Hawking's devices (Mialet, 2003), a 'pliant and diligent slave' (Latour, 1994, p. 31), as a passive prosthetic that 'transports meaning ... without transformation' (Latour, 2005, p. 39). If a 'Cartesian view of the world' is defined as the idea that 'human subjects or cognitive systems' are 'completely different from objects, i.e., material givens or artefacts' (Lang, 1993, p. 88), what B was after was a Cartesian Fix, a way to make Michael's mind visible as separate and distinct not only from his body, but from her efforts and any testing device.

Finding such a device wasn't easy. J was aware of global networks and could study exemplars elsewhere before he initiated the interactive video project. B, too, saw computers as the part of the answer, but beyond that had no clear idea of what to look for:

> This was just on my own ... I called all the universities around and I said, 'I'd like to take a course on how to use computers with people who are really disabled'. Nobody had a course ... . But because I'd called, a secretary remembered me when somebody got sick and dropped out of one of their research projects. And she called me and invited me to join this well-funded thing that gave me thousands of dollars of equipment. I had never turned a computer on. They didn't know that. So I just hung low and kept my mouth shut 'til I figured it out. And that was how I got my training initially. (2005 Interview)

Learning as she went, B first gave Michael an off-the-shelf scanning board that should have allowed him to indicate words and pictures by using switches to turn on lights. His hands flailed, however, and he quickly became exhausted. Moreover, the lights were so small that 'at times Michael didn't seem to know where he had stopped the light or which answer he had chosen' (B, 1992, pp. 236–237).

School administrators could have read these difficulties as failures of 'overt production' and taken them as evidence of Michael's untestable, retarded condition. The problem for them was political as well as empirical. Scientists working in new areas, for example,

> ... often have an agonizing choice to make: at what point have they done enough? ... A negative result or a set of such results may demonstrate, not the non-existence of some disputed phenomenon, but a failure of experimental technique. (Pinch, Collins & Carbone, 1996, pp. 169–170)

The school administrators, by contrast, also would have had to consider how much time and money should be expended to see if Michael, however configured, could hit the right switches. As they'd already categorized him as constitutively unable to perform intelligently, B's efforts would have appeared not just foolish but unethical and wasteful, taking resources from other children. For B, by contrast, this was not an experimental discovery problem and Michael's intelligence not a 'disputed phenomenon': She'd witnessed it already in events like the *Puddle Duck* episode. For her the problem was to close the gap (Lave, 1988) between what she'd seen manifested over time in embodied engagements, and what could be seen in brief and publicly reproducible demonstrations.

There's a parallel in Disability Studies, where theorists and activists distinguish between 'impairment' (limitations on activity produced by physical or intellectual conditions) and 'disability' (limitations produced by the social organization of activities). Being blind as opposed to sighted, for example, entails differences in access to certain phenomena, but the disabling implications of these differences for, say, one's success in school with sighted peers, are socially produced. In these terms B's problem was to shift understanding of Michael's overt production from the category of impairment to that of disability.

Impairment is far from stable, however (Thomas, 2004, p. 574). As Erevelles (2002, p. 16) argues, bodies are not static 'pre-social' (or asocial) bundles of capacities (normal

or impaired, cf. Kelly, 2005). What 'bodies' (and minds) are capable of depends on the networks of constant translation out of which they're assembled—their diets, environments, physical therapy, prosthetics, interactional opportunities and so forth. To get Michael tested, then, B had to assemble an entire network.

She had little idea how to go about this. Few people in the region could help (the university that gave her the computer was 120 miles away), and the low profile of the assistive technology field in the mid-1980s (Zangari, Lloyd & Vicker, 1994, p. 49) left her without access to works of potential relevance (e.g. Goossens, 1989). She had no training in technology, either, although she had watched her father, a repairman, at work. Her first idea was to get a circuit diagram for a scanning board from the state department of education and build one with bigger lights for Michael. She did, but the board didn't work. A teacher at the local vocational-technical school explained that the diagram was incorrectly drawn. When volunteers at the school built a working version, however, it turned out Michael lacked the muscle control to use the switches. B tried anchoring his arm to limit the involuntarily movements, but this quickly tired him, so she changed the type of switch to make it more compatible with the arm movements Michael could comfortably make. Now the problem was that the movements were so forceful he broke the switches. To deal with this, B taught herself soldering and began experimenting with different switch materials and placements (B, 1992, p. 240).

> I didn't even know the difference between rosin core and the other kind of solder. And I had to go and buy things and then adapt them by using this rosin core solder ... . I had to go and figure this out. (2005 interview)

The university project mentioned earlier gave her access to help she couldn't get locally:

> They put us on an internet connection when there was no web ... . And one night I actually got on ... sort of live at the time. A guy in Seattle talked me through how to solder this thing. And I was very nervous 'cause I'd paid $80 for this equipment. If I had broken it no one would reimburse me. They [the school administrators] didn't even know what I was trying to do. (2005 interview)

She had to hide her work from administrators in part because she was 'tinkering' with the device, that is, making it through 'a progressive selection of what works' in a particular situation (Knorr-Cetina, 1979, p. 369), 'using what is at hand, making-do, using things for new purposes, patching things together, and so on' (Clark & Fujimura, 1992, p. 11). Tinkering itself is not an illegitimate mode of work, but device-making and intelligence testing were clearly not part of B's job description, and the failures, mistakes, and recursive adjustments inherit in tinkering would likely have been taken as evidence of her incompetence and insubordination—she was, after all, trying to undermine her employer's decision—as well as of Michael's cognitive limits. Unlike J, she worked in an antagonistic environment dominated by a 'greedy' (Coser, 1974) network—a network that monopolizes the institutional or public definition of people by stabilizing associations that position it as gatekeeper or 'obligatory passage point' to resources they depend upon. Indeed, B herself was one of these essential resources, and she had to make the device work right the first time in public or risk a prohibition on further development efforts.

This turned out to involve more than she had anticipated. It became clear that Michael's ability to use the board was located not just in his hands and arms but in the positioning of his hips in the wheelchair and in the wheelchair itself (he was growing and needed a new one). Moreover, the ability to use a scanning board, like all abilities, is relational. Although Michael initially tired quickly, physical therapy helped him build muscle control, and B was able to get the school psychologist to adjust the testing procedures and allow Michael time to move the switches and rest when exhausted. In principle, as Winance (2006, p. 68) notes, this 'process of adjustment is continuous'. In this instance, however, once adjustments had produced a network that allowed Michael to reliably manipulate the switches, the cloistering of the development process could be abandoned, administrators and others informed of the work, and Michael could take the test to demonstrate himself as an intelligent, individuated child.

He did. And the administrators were not happy. 'The Special Ed[ucation] director for the country went to my principal and said, "Tell her not to do that again ... He said, "That's going to lead parents to unrealistic expectations".' B recalled in a 1989 interview:

> You spend your time and efforts and you prove this stuff. You put your own money into the technology because there is no budget for you, and you finally got this thing out, and everybody is going 'Drop dead. Get out of here. This messes up our view of things' ... . I didn't have tenure, and if I'd been younger with a principal who didn't back me up, I would have been out of the school system, really and truly.

She wasn't dismissed, but administrators followed through with their original plans and placed Michael in the segregated school.

The administrators had a reason to be worried. Michael became known locally among parents of children with disabilities as an example of the child-wrongly-presumed-retarded-and-redeemed-through-technology, and they eventually forced the school district to create a special class for him and others in a regular elementary school setting. As B recalled:

> It wasn't six months later they were bringing in the school board and praising me in the papers. You're praised for the wrong thing, and you're damned for the wrong thing. What you really do doesn't get noticed. (2005 interview).

Part of B's inability to control the public narrative of her work—to stabilize a new identity for herself—stemmed from the fact that, unlike J, who finished his doctorate before shifting the focus of his work, the urgency of Michael's situation had forced her to proceed without academic credentials or official license. *After* her work with Michael, however, B did return to graduate school, wrote a dissertation on her work with Michael, and gained a doctorate in Special Education Administration (from the same department in which J earned his, albeit in a different program). By this time, more and more parents were demanding access to alternative testing and assistive technologies for their children. The doctorate, on top of the belated publicity from her work with Michael, allowed B to move from teaching to become a technology consultant and assistive technology trainer.

> I did a lot of training of teachers all over the state ... . Always the school systems were way behind in the technology, and in many cases the parents and

> the advocates knew more of what was available. And if they didn't shout and scream and bring an expert, people would not do these things. So the Department of Ed and the various people said 'we've got to train teachers so they know more what to do'. And that was my job. I would run around training teachers. And I would do workshops on a specific device with clips of how my students use it ... . After I covered the whole state then I went back [laughs] ... I worked in fifty schools ... with students from eight school districts.

Some 20 years after her work with Michael, B returned to her old school district as a one-person AT unit (the administrators who had opposed her were long gone). When she'd last been a teacher there,

> ... the kids who got the AT generally had either people like me who chose them as guinea pigs to help them, or parents who were very vocal and insisting ... . They tended to be, in most cases, the better educated parents ... . That's not true anymore.

Now there were regulations requiring that AT uses be explored for children with disabilities, global networks developing such technologies, and advocacy groups disseminating information about them to parents. This reshaping of organizational boundaries to open arenas of school practice to the influence of parents and technologists now created problems for B in her role as a technician for the District:

> Parents [were] the big movers of assistive technology, initially ... . But it turned into being a bit of a problem later because then they would go off to some conference where someone would talk about a particular device and they would come back and demand that device. Well, the problem is if your insurance or your school paid what was then about $3,000 or $4,000 for some big hot-shot device they weren't going to buy another one six-months later when you found out that was the wrong one, and sometimes it really was the wrong one. And I would come in with something that was either more complicated or less complicated and the parents would have a fit because 'so and so said', you know.

Instead of tinkering and demonstrating, B's work now consisted of setting up and programming off-the-shelf devices. In the early days she had known 'every single augmentative communication device on the market [and] ... all of the major good software ... There wasn't a whole lot'. By 2005 each week seemed to bring a new product with a 100-page manual to master. Although her work now helped scores of children, not just a handful, B was no long an artisan working under the radar but something closer to an operative, an 'accessory to processes whose specification has been laid down in advance' (Ingold, 2000, pp. 295–96). She recalled that her father had:

> ... loved to take his tool kits everywhere he went. And when I first got into assistive technology, you had to do that. We had to up-end the [wheel] chairs and use our tools ourselves. We can't do that now. We would void warranties ... . At first, you felt like you were a repairman, an advocate, a

> teacher, a designer, but also a lawyer in the middle … . Literally, one-fourth of my house was equipment. I had turned my entire basement into nothing but a work area with a table five times this big with cabinets all around. The reason I did that [was] because no school system would give me the space I needed …
>
> Man, those days are a bit gone by. I now have a closet—unheated, cold, and it gets moved every two years … . But the thing is I do have a lot of money in equipment and devices.

For all these resources, however, she worried about how the devices were being integrated into the children's lives. The extended, inter-corporeal relations through which she had recognized Michael's skills and tinkered him into a successful communicative configuration were impossible to reproduce in the current school context. The technology and her role as technology specialist had shifted the focus to identifying, procuring, programming, and maintaining devices:

> The biggest support comes in knowing how the kid learns and how to set it up to get them going and to make them even care about using it. That's harder today …
>
> When I taught I learned why [the children] dropped it. And I adapted it. And then if I noticed they'd give it a little more time, I'd adapt it a little more. Then if I noticed they really did something, then I would figure out what it was that had engaged them. And that's how I would keep it going. Whereas if a person is overwhelmed … . Almost everything that administrators, secretaries, and support people did in those early days is now done by one teacher … I would not go into Special Ed today unless you paid me a million dollars, and … I'd use half of it to pay for assistance.

Conclusions

These last comments remind us that the historical-geographic junctions at which events unfold are keys to their meanings and implications. J and S were working on the problems described here at a time when broad waves of change—computerization, new disability laws—were sweeping through schools, and it might seem that rather than initiating device-mediated change they were surfing the waves of change. But broader movements are made out of the activities of people like J and S. From an ANT perspective, understanding change isn't a matter of locating individuals in 'larger' processes, but of mapping the translations, circuits, and performances that are assembled into such processes. The maps themselves presumably will be unique—historically and geographically specific—but the mechanisms of translation and performance and the strategies of stabilization and change should have relevance beyond the particular case. Just as ANT is empirically entailing—its full meanings emerging through case analyses—so its analyses gain resonance when translated or linked to other studies. I've tried to illustrate this in a limited way by noting some contrasts and similarities across the two cases. Without trying to summarize the work, I'll end by pointing to a few more.

It matters whether people and devices are attached through discretionary or obligatory associations. J and S could abandon the interactive video without losing the ability to teach, but Michael would lose a great deal without an assistive communication device (and for a while he did—at first his wheelchair and board were too large to fit in the trailer he shared with his mother and her boyfriend, and he lost access to communicative channels every day when he went home). Along another dimension, however, it was critical to the shift in identity that J was constructing that he remained (at least in the early years, until the task force report and the stabilization of his organizational unit) associated with *some* demonstrable device (hence the chain of grant-funded projects): His identity took years to stabilize. By contrast, Michael's transformation after the public demonstration was irreversible in the same sense that Stephen Hawking's history of communicativeness is irreversible: Denying Michael an assistive communication device does not return him to the category of a 'severely and profoundly handicapped' person. Once it is shown that such devices allow him to perform intelligently, denying him one becomes a category violation and a violation of his rights. Some translations are narratively indelible, then, others performatively contingent.

Associations also need to be differentiated in terms of the delay or immediacy of the translations they effect. As a demonstration of a future device, administrators and professors could invest in J's device or use it without changing what they did in the short term. Since 'courseware' was an unfinished and malleable 'boundary negotiating artifact' (Lee, 2007), it was possible to push decisions about translations indefinitely into the future. B's device, by contrast, allowed Michael to take the test and immediately claim his new identity. As school administrators realized, it also opened the system to immediate demands by other families of supposedly 'untestable' children.

Such differences had implications for the ways organizational boundaries were defined. Instructional technology devices were instruments for shifting the relations of the university to state bureaucracies and professional associations like the AECT. State funding priorities and policy languages became influences on classroom pedagogy in ways they had not been in the past; professors trying to introduce instructional technologies with the help of J's unit found their teaching realigned with instructional design fields.

In B's case, the problem for the school was that Michael's performance was a 'demo' not just of what *he* could do, but of what other children defined as retarded might be able to do with appropriate prostheses. The device did not simply suggest a role for technologists in 'testing', it implied a re-drawing (or weakening) of school boundaries in a way that gave parents grounds for making legal demands for assistive technology.

Finally, although it's been understood since the 19th century that a machine extends in space and motion to include the objects it works upon and the sources of its energy (Ingold, 2000), the cases here ask us to reconsider where artifacts begin and end in time—the temporalities of associations and translations. To make sense of the interactive video or the scanning board we needed to look at the histories of the people who made them, the labs, offices, and work tables they had access to, and the pace of their work against the calendars and time-reckoning systems of their organizations. Things, as ANT theories say, are full of people, congealed or 'dead labor' in Marxist terms, but as Abbott

(2005b) points out people often last longer than devices and their memories and knowledge can exceed what things can store or represent.

Devices are also embedded in people, then, and without forgetting that people are networked, far-from-equilibrium systems, we can understand some organizational changes, whatever the public narratives used to legitimize them, as emergent in a back and forth process in which the devices we make, becoming elements of our environments and articulations with the world, remake us.

Note

1. Both cases are presented schematically, with much of the story omitted. I once attempted to co-author a paper with B that would situate her work ethnographically in the local politics and parental advocacy around special education, but she complained that my writing gave her a headache. I hope this version is less painful.

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