The Analog Divide: Technology Practices in Public Education

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"a system is nothing more than the subordination of all the aspects of the universe to some one of them."
- Jorge Luis Borges

Introduction (Reconnaissance)

Countless parachutes speckle the smoggy skies over Los Angeles as thousands of computers are air-dropped into public schools. The educational war-zone of Los Angeles Unified School District (LAUSD) desperately needs these technological resources as ammunition in the war on poor academic achievement. When the computers hit the ground at local school sites, understaffed technology coordinators scramble to deploy the equipment within classroom outposts connected to trenches of copper and fiber cable that criss-cross each school site. More often than not, lines of communication between local officers and district generals are scrambled or cut. What is the plan once the computers are deployed? There is discord in the ranks, and some question the existence of any overarching strategy or purpose.

This military metaphor is used by school technology coordinators to describe the elaborate maneuvers of technology implementation in LAUSD. The district consists of 791 K-12 schools serving a multi-ethnic student population of 722,727 students across 704 square miles (LAUSD 2001). It is second in size only to New York City's school district. Because of LAUSD's organizational complexity, ethnic diversity, and large "at risk" student population, its educational reform efforts often influence similar reform projects in other school districts across the country. These reasons make LAUSD an ideal site for studying issues of technological access and opportunity. The district is currently targeted for massive amounts of federal, state, and local funding assistance in the form of information technologies, network infrastructures, and staff technology training. My primary fieldsite, an inner-city high school in central Los Angeles, will be receiving an estimated $5 million for technology over a five-year period (1998 to 2002). Access to technological resources soon will cease to be an issue for students at this high school and others schools in LAUSD. The district will bridge this "digital divide," but technological and educational inequities will persist. To understand why, technologies must be seen as operating within larger contexts of inequity: *the analog divide*.

The analog divide is rendered visible by focusing on practices within the *material, discursive, and symbolic* contexts of public education. The material environment is comprised of technological artifacts (like computers, books, and desks), spaces (such as classrooms), and infrastructures (such as school facilities and computer networks). Discursive contexts include individual relations, organizational communications, and policy negotiations. Symbolic contexts encompass cultural meanings and logics, which are associated with artifacts, images, discourses, and processes. Each of these contexts overlap and interrelate. One can study the interrelation of these contexts through *technology practices* that occur across them: technology design, use, and evaluation. This paper will focus on technology design in LAUSD in order to gain a deeper understanding of how design processes shape educational possibilities. I attend to technology design because this is a neglected area in studies of education and technology. By contrast, excellent research continues to be done on the instructional side of technologies in education (Bromley & Apple 1998; Healy 1999).

Here is another way to look at technology practice contexts: the many parachutes of computers over Los Angeles must eventually hit the ground. When they do, they will reverberate through these multiple contexts with varying degrees of dissonance. There is never a "clean" drop. There is never a seamless integration of technology. Therefore, it is misleading to equate numbers of computers with educational or social parity because these numbers float above practice contexts in a false realm of digital purity. Difference occurs on the ground in analog time. [1] At each school the damage resulting from this impact can be read as an indicator of the analog divide.

Technology Practice Modalities

My inquiry into technology practices resonates within its own theoretical contexts. De Certeau (1984) introduced an opposition between *tactics*, as improvised, transient appropriations of spaces, and *strategies*, as planned, durable, and disciplinary places. Bourdieu (1977) set up a similar tension between the realm of discursive possibility (*orthodox* or *heterodox*) and the governing logics of those operations that lie outside of the realm of discourse (*doxa*). With de Certeau, individual practices are constrained by external forces - materialities and rationalities; with Bourdieu, individual practices are constrained by internalized cultural logics. Both of these approaches provide useful starting points for practices inquiry. However, both approaches de-emphasize the ever-evolving co-construction of practice possibilities and structural constraints. In other words, the divisions between the tactical and the strategic or between the possible and the doxa are never so clear *in practice*.

The interdisciplinary field of science and technology studies (STS) offers some correctives to this exaggerated dichotomization. Pfaffenberger (1992) and Eglash (2001), for instance, proffer models of technology appropriation to account for ways that people transform technological artifacts, systems, and meanings. Put simply, technology appropriations are ways that individuals make technologies their own. Some technology appropriation examples include sleeping on bus benches, "tagging" artifacts with graffiti, or modifying automobiles into low-rider cars. Often technology appropriations reconfigure social power relations. For example, the Kayapo in Brazil employed video-recorders to document and publicize their protest of the Brazilian government's development of indigenous lands (Hess 1995; Eglash 2001). Eubanks (2001) complements these appropriation models by arguing that technologies designed at the margins, or for the marginal, are simply better because they take the specific needs of the disadvantaged into account. These designs will therefore work better for most people, since most people usually operate at the margins of technology design.

I suggest that these approaches to technology appropriation must be supplemented by a framework of *practice modalities*, whereby one can design for appropriation. After all, some strategically-engineered technological systems possess strong valences[2] for appropriation from intended uses. Streets intended for automobile traffic can be used alternately for walking, skateboarding, socializing, and playing games. Conversely, some less strategic designs can become quite disciplinary. I recall the poor spatial layout of a security system in Halifax's international airport: a make-shift passenger metal detector system was coupled with a luggage x-ray machine in such a way that a single employee had to run continuously around the machines (about 12') to return keys, coins, and watches to passengers. Great exercise, but inefficient, disciplinary, and inflexible design.

Flexibility provides a way to configure strategic designs for tactical appropriations. Flexible designs encourage multiple-uses and periodic re-design across contexts; such designs afford appropriation through their open and fluid structures (Monahan 2000; de Laet & Mol 2000). I take flexibility to be valuable in educational settings because it creates opportunities for learning through participation in design. Flexibility allows for the adjustment of designs (whether of technologies, policies, or pedagogies) to meet varying student needs.

In this essay I will trace technology design at one central Los Angeles public high school across material, discursive, and symbolic contexts. For each of these contexts, I will highlight the relationship between practice modalities and what I call the analog divide. Finally, I will suggest some ways to bridge analog divides through flexible designs.

Material Designs

A cadre of male college students[3] infiltrates a science classroom on the third floor of Concrete High School.[4] Equipped with boxes of category five copper cable (CAT5), duct tape, various pliers, flashlights, plastic ties, box-cutters, a ladder, and long coils of bright orange polyvinylchloride (PVC) conduit, they set to work on a cable "pull" to connect incoming computers to a currently non-usable school network. This part-time school technology staff works as a team. One worker steadies the ladder as another ascends. He exercises caution when removing dusty panels from the drop-ceiling, for empty bottles, cans, and dead pigeons are frequent finds in these overhead caverns. PVC tubing is passed up to the worker whose head is concealed within the opaque void where the ceiling tile was. The workers joke about the unpredictable elasticity of the tubing, which can smack one in the face or cause one to slice his own hands with razor blades while trying to cut it - both events have happened in the recent past. The worker on the ladder strings the conduit from one ceiling tile to another (where the CAT5 will be pulled to) and uses plastic ties to secure it. This placement is complicated by the need to avoid the fluorescent light fixtures that play havoc on data signals. Once in position, the group cuts the conduit to the necessary length and triple-ties and tapes the cord that runs throughout the tubing to the tube's end. They are now ready to "pull cable" yet sense that a day's work is done. The always-on emergency fluorescent lights flicker and hum as the technical staff retreats silently out of the classroom.

Students at Concrete High view these activities and space intrusions with vague curiosity, as welcome distractions from classroom monotony. The episode described above occurred after school, but similar technical work is often conducted during class hours. Teachers at this school view such restructuring with guarded suspicion. Many of these teachers believe computer literacy to be necessary for students to succeed after high school, but their own pedagogical uncertainty and territoriality compel them to resist. Nonetheless, the state of California has recently mandated a 4.75-to-1 student-to-computer ratio[5], so all classroom spaces are changing rapidly in spite of resistance.

We can begin to address the politics of classroom redesigning by acknowledging how materiality and spatiality shape experience and practice. Winner (1986), Sclove (1995), and others have argued that technological artifacts and systems function as political agents, which often structure social relations in unequal and undemocratic ways. Lefebvre (1991), Soja (1996), and Davis (1990) advance parallel arguments to address the politics of space. In educational settings, one can readily spot material and spatial politics. Lecture-style classrooms all but demand disciplined bodies, centralized authority, and one-to-many information-transmission. Cluster-style classrooms, by contrast, discipline bodies in less severe ways, decentralize authority, and encourage a plurality of communication. I call these spatial valences *built pedagogies* because they teach occupants about proper comportment. Built pedagogies act to configure bodies in space.

The description of workers preparing a CAT5 cable pull emphasizes the often hidden materiality of technology design. Classroom designs for technology establish further built pedagogies in their integration with existing spaces. For example, the very presence of visual images on computer monitors draws students' attention away from all auditory stimuli such as instruction, discussion, questions, or even the class bell. Computer monitors have a profound material-virtual effect upon social possibilities in these spaces, and several school sites have implemented network management programs that freeze students' screens in order to combat this attention problem. Computer monitors on desks also introduce classroom visibility complications that hinder other visual learning experiences, such as viewing the blackboard, teacher, or other students.

Networking computers in existing classrooms usually requires that desks touch the walls somehow, since this is where the electrical conduit and data drops are located. This poses further complications: if desks must always tie back to the wall, then one cannot move furniture in the class. Electrical lines are often enclosed in metal pipes to protect them and students from harm. This impermeable casing, coupled with warranty restrictions, prevents even technical staff from re-designing rooms. Teachers and students must adapt their activities to the inflexible structures that surround them.[6]

The integration of technology betrays an exclusionary politics on the material level. The built pedagogy is one of students and teachers adapting to the constraints of their technological worlds, not one of designing their worlds with technology to meet their needs. Authority may become displaced in these classrooms, but it is delegated to the technical infrastructure and not to the human participants. Ironically, unlike examples of voluntary technology delegation for purposes of human efficiency or discipline (Latour 1992), this material transference of classroom power to technology is largely the unintentional result of designing for network efficiency rather than learning enhancement.

That said, technology coordinators at schools, and the individuals laying the networks in these rooms, do care about creating effective learning environments. They operate within their own set of constraints that limit design possibilities. Their budgets do not include much money for furniture; they face opposition from teachers and staff; they are under strict time pressures; they must design around existing classroom obstacles such as tables bolted to the floor. Still, their network designs for classrooms are improvised. The technology staff's design practices are strategic in that they structure material contexts that impact the experiences of others (students and teachers), yet tactical in that they muddle their way through obstacles in *bricoleur* fashion.

Material designs reveal one front of the analog divide. On this front, the analog divide reverberates through potentialities of 1) participatory design, 2) flexible design, and 3) organizational communication. First, participatory design (the design of spaces, technologies, or systems in meaningful collaboration with occupants or users) has been shown to ameliorate power inequities, invest users in design processes, and yield better designs (Schuler & Namioka 1993; Norman 1998). Participatory design is one process for achieving flexibility and creating tactical spaces. At Concrete High, students and teachers clearly were not invited to participate in the design process.

The potentiality of participatory design at Concrete High was exacerbated by time constraints and cultural obstacles. Participatory design demands time that cannot be taken under current technology implementation deadlines. Participatory design must also overcome cultural obstacles in the form of meaningful individual investment. For instance, I sought out the teacher of the science classroom described above and requested his input on the furniture layout for the computer portion of his classroom. His complete disinterest startled me until I discovered that this teacher did not want to use the computers being installed in his classroom anyway. Without the teacher's involvement in the initial framing of the design problem (under what circumstances should computers be used in public education, how should they be used, and for what purposes or pedagogical goals), my question was meaningless.

Second, flexible design at Concrete High is constrained by existing inflexible structures. As outlined above, inflexible structures take the form of bolted tables, electrical outlets in awkward places, impermeable electrical conduit, inconvenient fluorescent light placement, glare from windows, and, perhaps worst of all, the need for at least forty seats in each classroom. Highly aware of these constraints, the technology staff attempts to build some flexibility into their new designs. The technology staff does not bolt tables to floors or computers to tables. They pull more cable through conduit than is currently needed "in case something goes wrong." Finally, they try to select network equipment that will be compatible with any other equipment (for instance, they avoid some proprietary switches that are not compatible with switches made by other companies).

Third, organizational communication is disrupted or non-existent between many groups within and without LAUSD. These communication problems foreclose opportunities for participatory design. For instance, contractors hired by the district from a local school construction bond (Proposition BB) did not consult with individual schools about where to put individual data drops. These contractors were in contact with complex project managers within the district and presumably with the district's centralized instructional technology division (ITD) in downtown Los Angeles. Nonetheless, according to technology staff at the school site, schools were never consulted directly or even informed about the placement of these drops. This lack of consultation resulted in drops located in places that do not make sense for use - like in the middle of the library floor, far away from electrical outlets.

Reduced organizational communication becomes even more violent when construction must be coordinated between multiple funding sources. Because separate contractors were never in communication with each other, Concrete High was left with a T1 router (which routes data to and from the Internet) disconnected from the network's main data frame (MDF). Not only are there no resources to connect these devices and get the network operational, but the MDF is housed in a hermetically sealed metal case with no access for wire connections. The case will have to be drilled through in order to make this connection; this drilling will invalidate the warranty on the equipment, naturally.

One way to measure the analog divide is along the front of material design. Practices demonstrating breaches in participatory design, flexible design, or organizational communication will encounter many attacks on the path toward effective material designs. Conversely, practices exhibiting few disturbances in participatory design, flexible design, and organizational communication will better achieve material designs (or built pedagogies) for increasing student opportunities for learning and empowerment.

Discursive Maneuvers

What follows are conversations from fieldnotes and listserv electronic postings on the coordination of local bond monies (Proposition BB) and federal technology discounts (E-Rate) to implement a telecommunications network at Concrete High. These excerpts demonstrate a type of *splitting-and-inversion* whereby the process of fact construction is separated from the outcome. Science studies researchers have shown how scientists deploy this rhetorical device to persuade themselves and others that the end result of scientific inquiry (fact discovery) has nothing to do with the steps taken to arrive at those facts (fact construction) (Latour & Woolgar 1986 [1979]). In the case of delineating a plan for network implementation at Concrete High, strategic power is mobilized by those speaking for the district so that the tactical negotiation process is covered up.

10/16/2000 (Conversation with school's technology coordinator):

> The E-Rate people are going to rip out our current [not yet operational] [Proposition] BB network and then install their own, because E-Rate can only be used for new equipment, not upgrades.

10/27/2000 (Conversation with a school technology staff member):

> The plan is to tear out some 30 BB switches and replace them with a combination of hubs and switches with E-Rate money. We'll have one switch for every 3 to 4 rooms. The fiber drop in each room will then run from room hubs, to a lesser quality E-Rate switch, and then into the server. We only found out about this stupid plan half-way through the network implementation process.

11/01/2000 (Conversation with school's technology coordinator):

> Most schools don't have this BB and E-Rate conflict because they weren't first in line for BB money . . . The district [LAUSD] realized that networks would cost too much, yet they promised voters BB would put the Internet in every class. The district wanted this money for other needs: bathrooms, fire alarms, paint, etc. District restructuring solved this problem. BB could now be used to wire the more affluent local districts [7], and E-Rate could be used to fund wiring in the other schools.

12/11/2000 (Concrete High technology committee meeting):

> E-Rate won't take the BB network or switches out. Instead we'll have 2 parallel networks. BB will consist of CAT5 and switches. E-Rate of fiber and hubs. The goal will be to try to connect them.

01/25/2001 (Local district technology meeting):

> The plan has changed. Now E-Rate won't pull the BB network out of Concrete High. Instead, every classroom should get a fiber drop. They need to do this by July 1 or miss the matching funds deadline.[8]

02/01/2001 (Local district technology workshop):

> E-Rate has given $157 million. If all schools aren't wired by June 30, they'll take it back! It will make Belmont [9] look like peanuts.

02/05/2001 (Interview with local district instructional technology applications facilitator (ITAF)):

> BB and E-Rate at Concrete High is an ongoing saga. First the two were going to function complementary. Then they were going to rip out the BB net. Then they were going to put in two parallel networks. Now they're planning on ditching E-Rate altogether and taking the fine.

03/10/2001 (E-mail posting on district's technology listserv by Concrete High's technology coordinator):

> "The original e-rate plan (still the only e-rate plan, as far as I know...and I may *not* know, I emphasize that) called for e-rate subsidized installations of the new standard (2 fiber drops in classrooms, etc . . .) in all schools that had students included in the data submitted to the feds. So, originally, we at [Concrete High] were going to get an e-rate network, which would have been put in parallel to (but not necessarily connected to) our Prop BB network. When it rains, it pours, as they say. However, it became clear to District personnel and to the overseeing contractors . . . that there was no way they were going to be able to find enough subcontractors to be able to meet the federal e-rate deadlines if they had to wire all the schools, including those that had Prop BB installations underway . . . Thus, as of now, [Concrete High] (and the other schools that have Prop BB installations underway and, maybe, some schools that have other-sourced network installations in place) will not be getting the e-rate networks. We may be getting some supplementary benefits, but we will not be getting the fiber connections to each classroom and so on.
>
> So the short answer to your question is (1) not all schools are getting e-rate networks (even though the students in the schools helped qualify the District for the funds...I'm not sure how the District and the feds are dealing with this, seemingly difficult compliance contradiction, but they must be), and (2) schools are on all sorts of schedules, though the e-rate schools are all supposed to be finished, inspected, signed-off by end of June."

03/11/2001 (Summary of response to previous quote on district's technology listserv [10]):

> To the above posting an administrator from the district offices commented that the district *never* intended to construct two networks at Concrete High. Implementing a network where one is currently operational would violate compliance rules of the federal government's technology discount funding through E-Rate. The administrator advised readers that many people were unclear about the logistics of E-Rate and that people should contact him/her to get the true facts. This person added that the district just revised E-Rate specifications, and people should contact him/her to get these new specifications.

In terms of technology practice modalities, the last response above seeks to erase the tactical moves that constitute the plan for network implementation at Concrete High. If such an erasure is successful, only a strategic and legal plan will remain. This erasure does a disservice, however, to those who engaged in on-the-ground communicating, complaining, sharing, commiserating, and arguing in a variety of settings: individual interactions in school hallways, offices, classrooms, and parking lots; school-based technology meetings in libraries and conference rooms; local district technology meetings at school sites, community centers, and museums; district level technology meetings at school sites and in downtown conference rooms; numerous private phone calls and e-mails; and asynchronous public discussions in on-line forums. These discursive practices not only catalyzed the outcome of a functional plan, they also constitute that plan.

Importantly, those speaking authoritatively with the voice of the district engage in similar strategical and tactical maneuvers but with a different set of goals: district and personal accountability, protection, and legality. When the district representative says that the district *never* intended to construct two networks in Concrete High because that would violate E-Rate compliance, he/she is reminding readers about the importance of maintaining a unified front in matters of district accountability to the public. Reminding others of the necessity to protect the district is a strategical move within this community. This move exercises power over the other participants in this forum, reminding them of their places within the LAUSD hierarchy.

The district spokesperson next reveals traces of how the final strategic plan is solidified through tactical discourse. He/she warned about widespread misconceptions regarding the E-Rate, instructed people to contact him/her to get the facts, and then confided that the district recently revised E-Rate specifications. By juxtaposing the misconceptions of others with his/her facts, the district administrator dismisses and devalues all other understandings of the plan except for the one that he/she hoards. By communicating about revised specifications, he/she betrays the fact that all the answers may not have been known up front. This admission may later undergo its own splitting-and-inversion, or it may be used as a form of inoculation (Barthes 1957) where the district avoids scrutiny by admitting some past errors while claiming to have since corrected them. The district administrator performs at least two types of tactical rhetorical moves: de-personalized validation and personalized territoriality. In the former, the spokesperson's conflation of his/her voice with that of the district's is a move designed to deflect personal attacks onto the district itself. In the latter, claims of possessing specialized knowledge establish this person as an empowered gatekeeper that others must respectfully approach if they desire access to that knowledge.

Discourse is a necessary part of technology implementation. It is the means by which materiality takes form and acquires meaning. As the exchange between listserv participants illustrates, appropriation permeates throughout discourse. In order to catalyze the process so that Concrete High would not lose out, the first listserv participant challenges district knowledge and power. This challenge is more of a tactical move, because it operates within disciplinary structures rather than creating them. The district administrator responds by clarifying a plan for implementation and thus re-claiming some of the power in question. The district spokesperson's move is more strategical, because it enforces a disciplinary regime of gatekeeping to which others must adapt. This discursive engagement worked well: a definitive plan was articulated for Concrete High and the district protected itself. Furthermore, as a result of this listserv debate, the district awarded Concrete High the gift of a promise to connect their T1 router and MDF at the district's expense.

The discursive realm of technology practices reveals the analog divide by way of social power relations. I wish to stress the value and utility of the interpretive and iterative development of ***the plan*** for network implementation at Concrete High. The constant negotiation and knowledge construction was necessary and productive - it achieved an acceptable outcome while putting people in contact and conversation with one another. This negotiation process should not be overlooked in any evaluation of network implementation. That said, the process could have been more constructive and effective - materially and socially - had there been fewer obstacles to communication. In this discursive context, we should measure the analog divide not by comprehensive, disciplinary plans, but by opportunities for meaningful participation in the on-going creation, re-creation, and use of plans.

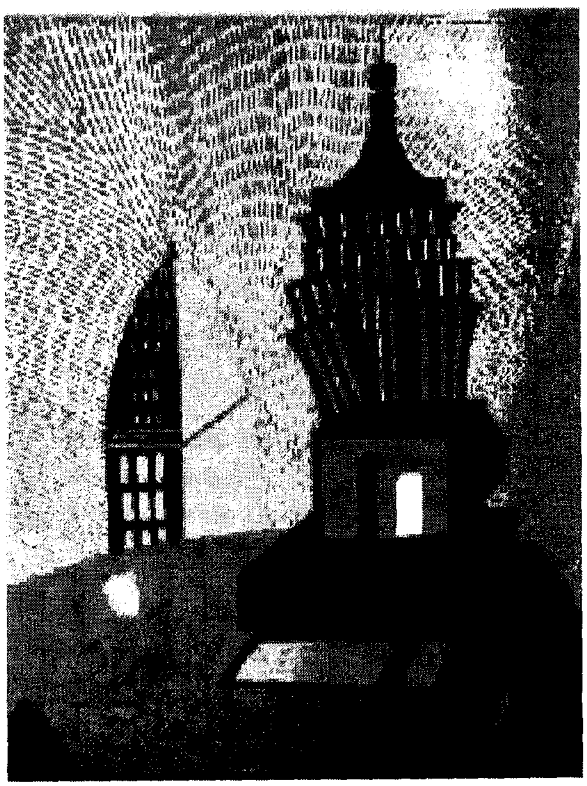
This section has shown how territoriality can aggravate the analog divide by impeding discourses of communication and negotiation. My informants label such territoriality *firewall culture*, after security systems that protect electronic networks from outside scrutiny or tampering. These types of territorialities can be seen as part of a larger historical and global trend toward internalized rationalities of accountability. As such, territorialities in LAUSD are a combination of protective strategies of existing groups and a newer *audit culture* (Strathern 2000) movement of self-policing for the sake of legal compliance.

When the end-goal of technology implementation becomes the avoidance of territory re-mapping, then implementation based on informed debate and collective participation becomes a secondary goal. Flexible alternatives to these protectionist moves would consist of fewer firewalls, more discussion, and more mechanisms to channel critiques into re-design. Such alternative discourse models entail more than organizational decentralization, however; they require a relinquishing of territories across the informal networks that persist in "decentralized" LAUSD and similar organizations. Moreover, alternative discourse models need to regulate audit culture logics that direct disproportionate attention to issues of individual accountability. Such alternatives would not simply shift the blame to everyone, but would move past the issue of attributing blame and instead plan for the complexity and indeterminacy of large-scale technological enterprises.

Symbolic Interpretations

Symbols operate as units of ritual that express what is relatively unknown but integral to cultures (Turner 1967). Symbols offer sites for the analysis of structurally invisible meanings within everyday rituals. Signs, by contrast, function as representations of "the known." The study of signs through semiotic analysis often privileges form over practice, subsequently sidestepping how readings of works or artifacts connect to social structures (DeNora 2000). How do the symbolic effects of information technologies perform in the educational world? How do symbols interpret us as we interpret them? As with material and discursive contexts, symbols of technology are designed in strategical and tactical ways. A brilliantly colored student mural outside of a Concrete High computer lab provides a window into this symbolic realm. Step up to the mural and take some readings (see Figure 1).

Figure 1: Student Mural at Concrete High



Mural description:
An enormous black-boxed computer presses down upon a rich green continent in Earth's northern hemisphere. The monitor screen projects an austere red, green, and yellow bar graph against a turquoise backdrop. The computer's mouse creates an island in a dark blue sea. An orderly pile of cash and coins has been stacked to the left of the machine. Two skyscrapers in the background tower over the computer and its planet. The art-deco Chrysler building soaks up orange sunlight with one face while shadows engulf its second visible side. The multiple-tiered Empire State building pierces the sky with red asparagus-like folds and a black spire, both immune to external colors of light or shadow. In Impressionist style, numerous gray rectangular marks betray systematic formations within the sky's nectarine and yellow radiance.

Student readings (Act 1):

Monahan: "What do you think this mural means?"
Student 1: "Everything in this wall, the computer is like taking care of everything."
Student 2: "Money, government . . . how much people make a year, I guess.
Monahan: "Why is it here in school?"
Student 2: "Because that's what students need sometimes. They need to make money. To pay taxes!"
Monahan: "What do computers have to do with that?"
Student 2: "The future, the future are the computers."
Monahan: "And the buildings?"
Student 2: "The buildings? The-ummm. I guess - it depends on your point of views."
Monahan: "What's your point of view?"
Student 2: "My point of view, maybe the buildings are there to, maybe some rich people are own the buildings, money on top of everybody. I guess, on top of the highest floor."
Student 1: "The money means the computers cost money, so don't mess with them. Don't mess with the computers in the classroom. It costs money."
Monahan: "And do you think the computer can help you get money?"
Student 1: "Well, you know. It helps people, you know. It helps people to get money, you know."

Student readings (Act 2):

Monahan: "Why is the computer on top of the world?"
Student 3: "On top of the world? The world can't go nowhere without any technology, which computers run most technology now. And they're run by computer chips."
Monahan: "So the world can't go anywhere; it can't even spin without the technology?"
Student 3: "Nah, it can spin but, you know? [Laughs]"
Monahan: "How 'bout the money?"
Student 3: "And the money? Probably you need money in the world to be someone 'cause - the United States, we're not as close to needing money but third world countries like, it's corruption and all that, so. It lets United States take advantage of third world countries."
Monahan: "What do the computers and the money have to do with each other?"
Student 3: "Computers and money? You need money to make that [the computer]. You need money to make the computers and all the software, so..."

Student readings (Act 3):

Monahan: "What do you think this mural means?"
Student 4: "The world is full of knowledge and money."

Teacher reading:

Monahan: "What do you think this mural means?"
Teacher: "The modern technological age is civilized by these high buildings, and cash - all emerge from the computer. So if you wish to be a modern person and make money in the modern world, you must first master the

computer. That's what I see."

Foreground reading:
In different ways, all the readings above respond to and agree with the symbols depicted in the foreground of this mural. Computers rest upon the world as they would upon a desktop. Computers dominate the globe, but in reciprocal relation to money and power. In this register, the screen image of a bar graph indicates that people can graph their way toward capital accumulation through these assembled signs (computers, buildings, globe, money). The computer and money support the material backdrop of business infrastructures (skyscrapers), but computers also gain prominence over buildings and business as they occupy the center of this mural and the center of conversation.

The mural betrays shifting technological experiences from massive, visible human projects to no less massive, hidden telecommunication networks and virtual experiences. The sense of awe of physical dominance provided by skyscrapers, what Nye (1996) calls the technological sublime, is replicated through the simultaneously ubiquitous and hidden qualities of telecommunication infrastructures. They are everywhere yet mysterious. This mystery affords hegemony over the definition of symbolic meaning, so that artifacts, such as the computer, are equated with knowledge, modernity, power, money, and even education. As the student indicated above, power over computers resides in elite places of business on top floors of skyscrapers. I would extend this interpretation of business power to include the power to shape the symbolic content of information technologies through advertising, marketing, lobbying, et cetera. Technology practices are inflected by such internalized and naturalized meanings that are *downloaded* from other sources and applied to different contexts (as my word choice illustrates). This is one way that symbols interpret us.

Background reading:
None of the people I stopped in the hallway had anything to say about the textured background of the student mural. But these gray rectangular sunbursts give meaning to the foreground images that they circulate neatly around. Indeed, there would be no "foreground" without this "background." What do these orderly marks do? Like students, they line up, merge, and flow. They adapt to, while maintaining, the foreground symbols. On a human level, these marks communicate the need to maintain individuality (and accountability) while flexibly adapting to the built, technological world. These marks merge with student lockers which surround the mural and bleed into the hallways where students roam. Mobile students become the necessary paratextual background for the mural. Student interpretations contextualize the mural so that it can soak up meaning; the mural then re-interprets the students by reifying dominant meanings of technologies.

Students must craft flexible identities in order to adapt to symbols of technologies "running the world" and "modernizing civilization." As Martin (1995) has shown with her research on corporate business training, individuals are conditioned to link personal success with innovation and risk-taking. Businesses value employees that flexibly adjust to workplace vicissitudes, allow work-life to pervade personal-life, and accept organizational interdependency with passivity. The prevalence of these logics can be witnessed in best-selling business motivational books that advise employees to visualize but never analyze (Johnson 1998). Thinking is an impediment to success in this emerging new economy. The internalization of these logics results in a state of *empowered powerlessness* whereby irrational, manic personality traits meet the needs of "rational" market forces (Martin 2000). Workers are empowered to exploit themselves but not to change the system of exploitation. As the next section will demonstrate, the types of flexible identities students interpret for themselves often do not match the rigidly exploitative ones advocated by academic or business institutions.

Reading practices:
The symbolic meaning of artifacts is articulated through words but also practices. Students may accept and repeat dominant rhetorics (that occupational success requires technological literacy), yet they simultaneously invent new meanings crafted to specific contexts. In addition to academic activities, students and teachers use computers as instruments of escape in the classroom, where they can "legitimately" ignore each other and their social roles. Through computer repair, programming, and gaming, Concrete High's student technology staff creates a strong sense of community based upon an elaborate apprenticeship structure. Other students initiate personal communication and expression activities with computers: chatting with friends in other countries with instant message (IM) software, designing personal and business Web pages on free servers, composing letters and poems for others, sharing music files through Napster or MP3, typing resumes for potential jobs, and so on.[11] This range of alternate technological uses betrays individual and collective agency in symbolic inscription. Through practice, students appropriate technologies on the level of symbolic meaning. Information technologies come to mean much more than artifacts that one must flexibly adapt to in order to succeed; they also come to mean what they facilitate - escape, community, communication, and self-expression.

In this symbolic context, foreground and surface meanings of technology dominate. Students and others borrow these meanings - which equate technological literacy with success, the future, and modernity - from popular media and culture. Because these meanings circulate so widely, individuals interpret them as "common sense" and subsequently cease to question their origins or validity. Parents and students come to want technological literacy without really knowing what it is or what it can be. In this sense, foreground symbolic meaning is overdetermined and strategically structured. It resists alteration and disciplines opposing interpretations.

Interestingly, students build upon the foreground meanings of technological necessity in order to challenge background meanings of self-adaptation (see Figure 2). Students mobilize the rationale of technological necessity as a support for their non-adaptive practices. The presence of computers in classrooms, and adult sentiment that students should be using them, creates a tactical maneuvering space for students to create their own symbolic meanings. Students use the technology but not only to adapt. Through appropriation, students inject meanings of escape, community, communication,

Figure 2: Symbolic Interpretations of Technology

Technological Necessity	Individual Adaptation	Technology Appropriation
(Foreground)	(Background)	(Practices)

self-expression, or even destruction into the symbolic context. The background symbolic meaning of student adaptation is underdetermined and less strategic than the foreground meaning of technological necessity. This background meaning allows for student re-interpretation through practice.

Symbolic interpretations enforce analog divisions at least as much as material designs or discursive maneuvers. The policing of interpretive borders between foreground, background, and practice meanings restricts imagination for difference. More flexible symbols less constricted by corporate media, market frameworks, or accountability concerns would allow symbolic interpretations to move from the background of activities to the foreground of imaginaries. By encouraging students to invent technology uses and meanings that make sense to them and incorporating these meanings into education, educational systems may benefit from student innovation and investment. Turner (1967) asserted that the liminal stage of transition presents the ideal moment for cultural reflection. The ongoing technological transformation of public education affords a unique liminal opportunity to break down symbolic barricades that imprison the possible.

Conclusions

Jorge Luis Borges' quote, which began this article, stresses the necessary insufficiency of all systems of analysis. Troping public education as a technological war-zone of digital divides performs a certain violence upon analytic categories, which in turn damages meaningful opportunities for reform. As with military air-drops, attention to the digital divide artificially focuses attention upon a single point of experienced reality: technological artifacts. This perspective is digitally discreet and clean, but it lacks context and depth - single points can be seen only in one dimension. Adding discursive and symbolic dimensions exposes the analog depth of technological artifacts. Rather than being viewed as disembodied points, technologies become material relations in space. In combination, material, discursive, and symbolic analyses can disarm digital thinking.

Drawing upon ethnographic data of the design of technological infrastructures in Los Angeles Unified School District (LAUSD), this paper has advanced a framework of *technology practices* that makes three theoretical contributions. First, it extends de Certeau's largely spatial framework of strategies and tactics to material, discursive, and symbolic domains. Second, it reveals modalities of negotiation and appropriation in the middle ground between strategies and tactics, between the conceivable and the possible. Third, the technology practices framework raises questions about the danger of reading militaristic strategies and tactics in(to) design.

This paper has demonstrated that material designs, discursive maneuvers, and symbolic interpretations enforce discipline and/or appropriate power in ways comparable to spatial strategies and tactics. Across each of these contexts, practices are constrained by forms of life that are tenacious and durable. Material infrastructures restrict design modifications and additions while supporting certain social activities and deterring others. Discursive and symbolic structures are informed by cultural values and assumptions, codes of acceptability, policies, media images, and so on. Because discursive and symbolic meanings are so often taken for granted and un-analyzed, their power to shape design practices can be extremely influential. Yet, as this essay has shown, discourses and symbols are themselves designed through practice.

Evaluating technology design is complicated by modalities existing between strategies and tactics. In these middle spaces, tactical moves for one group can be interpreted as strategic by another, and vice-versa. This is demonstrated in the material design context by the improvisation of Concrete High's technology staff. In this case, teachers may view the staff's tactical negotiations of materialities as strategic invasions of personal territory. Similarly, in the discursive context, the district spokesperson adeptly maneuvers through the strategic realm of audit culture, yet these same discursive maneuvers discipline collective knowledge construction by others. Finally, in the symbolic context, dominant meanings of technological necessity enforce a strategic regime that interprets any critique as irrational and anti-technological. Students then poach upon this same rationality to create their own meanings through appropriations of the "necessary" technologies. The presence of these modalities encourages evaluative research that analyzes individual, situated contexts for the ways that they create larger assemblages of practice possibility.

Because studies of strategies and tactics operate within militarized metaphorical zones, they call for critical reflexivity. Infrastructure design in LAUSD is more than a range of strategies, tactics, and appropriations - it represents an experimental moment in education. This moment is fed by the lived experiences of individuals involved in the process and by the projected needs of "at risk" students. Design for technology is itself a *creative act* - it creates an infrastructure. This infrastructure is then creatively interpreted by students and others. To categorize creations within a militaristic framework of strategies and tactics de-values them. More accurately, such categorizations choose to value what is aggressive about creation: the manipulation of territories. An alternate framework would view creative acts through a lens of symbiosis. Through this lens, creative acts would be evaluated by what they catalyze, not how they (re)territorialize.

The technology practices framework developed in this paper brings the digital divide's parachute to the ground and places the debate within specific contexts of meaning. This grounding offers a corrective to analyses that put excessive faith in technological fixes to social problems. The term analog divide, then, accounts for inequities that persist in education and other domains in spite of technology access. One can begin to address the analog divide by 1) including material, discursive, and symbolic contexts in analyses, 2) recognizing third spaces between strategies and tactics, and 3) pushing for categories that value creation and flexibility over discipline and control. The point of these distinctions is not to suggest that some analytic approaches are right and others wrong, or that any of them are mutually exclusive. Rather, I hope to shift the emphasis, and thus the conversation, away from topics that occlude difference, complexity, and opportunities for meaningful change. Analog thinking promises new forms of life and learning.

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End Notes

[1] I employ digital and analog metaphors based on my informants' discourse. They trope digital as pure, discreet, discontinuous, and disembodied, and analog as tainted, relational, continuous, and embodied. A more technical definition would describe digital as information referenced to a code table based on arbitrary symbols, and analog as information embodied within and constituent of physical representations (Eglash 1998). Informants' definitions of "analog" articulate a nice colloquial expression of technology co-construction. Individual practices (as analog signals) change the configuration and meaning of technologies (the physical representations of information). Reciprocally, technological configurations and meanings (information representations) shape the range of perceived possible practices (the signal is constrained by its physical medium). Understanding the analog divide, then, requires attention to the ever-evolving co-construction of technological systems.

[2] Corlann Gee Bush (1997) adopts the term *valence* to account for predictability in technology uses or outcomes. Technologies are charged differentially for a range of uses, and no technologies are neutral.

[3] The absence of women in this narrative is intentional. At this school, I have witnessed only one woman working as part of the technology staff, and she served as a computer lab aide rather than as a participant in design. This observation is consistent with national U.S. studies indicating that women account for 20% of IT professionals (AAUW 2000). At the same time, as one of my male interviewees pointed out, women now comprise over 50% of World Wide Web users (Brown 2000). Differential access to technology design persists even as access to technology use opens up. This division along sex lines represents one important aspect of the analog divide. (It should be said that the valuing of technical professions over social ones (such as teaching) reveals that gender inequities go way beyond issues of technology access.)

Still, my research findings show an anomaly in this trend of access to technology design: women do occupy many lead positions in LAUSD's technology coordination efforts - I'd estimate 30-40%. I attribute this to the first phase of an emerging IT class that has drawn its personnel largely from teaching staff. This group is gaining more control over school territories and displacing power held by teachers and administrators. This is a unique development in a public education culture where male administrators have historically introduced technologies to gain further control over female teachers (Cuban 1986). Now many LAUSD administrators are scrambling to maintain control too. I predict that LAUSD will eventually invest in trained IT professionals from outside of educational fields, and then, unfortunately, this emergent IT class will replicate gender inequities in industry.

[4] This name is fictive but definitely descriptive.

[5] California State Assembly Bill 2882 dedicates $175 million for public high schools to meet this ratio. Technically, bills like this one do not "require" schools to apply for the funds and comply with their rules. However, since public schools are in constant need of funds, any missed opportunity to secure "free money" would be interpreted as negligent or incompetent. LAUSD's accountability culture provides little room for schools to opt out. In the case of AB 2882, the information technology division (ITD) of LAUSD has assumed control of purchasing authority, stripping this minor degree of autonomy from individual schools. My informants indicate that this type of centralized control will be standard practice from now on.

[6] Wireless technologies may solve some of these problems, but they require their own technological infrastructures and dependencies. Moreover, many schools do not have sufficient electrical systems, functional HVAC systems, adequate furniture, acceptable lighting, and so on. There is no simple technological fix for poor learning environments.

[7] LAUSD was restructured in the summer of 2000, prior to Roy

Romer, former governor of Colorado, accepting the job of district superintendent. Interviewees interpreted district restructuring as an inoculation against public demands for accountability. When I use the term "local district," I am referring to one of the eleven districts (complete with superintendents and staff) that now make up LAUSD; when I say "the district," I am referring to LAUSD as a whole.

[8] In May 2001, LAUSD received an extension from the federal government for E-Rate technology discounts. The new deadline for network completion is September 30, 2001.

[9] The Belmont Learning Complex debacle: a $200 million LAUSD school was built on a 35-acre former oil field with toxic levels of hydrogen sulfide and potentially explosive methane. This nearly completed project was abandoned in January 2000 (Smith 2000).

[10] The administrator from the district offices requested not to be quoted.

[11] Concrete High's network is not officially connected to the Internet at this time. In other words, the district has not signed over network ownership to the school. That said, a previous ad hoc local area network (LAN) is in place, and students can access the Internet in the library. Since the student technology staff runs the network, they know the passwords for accessing the Internet, and they use it frequently in their lab. This access is highly self-regulated, however, by an internal system of hierarchy based loosely upon tenure.

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