Draft

Towards a Critical Anthropology of Science and Education

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Introduction: Schools in the Anthropology of Science's Public Culture

This paper outlines an anthropology of the intersection of science and public education. The last fifteen years have seen the remarkable emergence of an anthropology of technoscience; from the anthropology of laboratories (Latour & Woolgar, 1979/1986) and the lives of communities of scientists (Heath, 1994; Traweek, 1988), to cyborg anthropology (Gray, 1995), and Chris Toumey's (1996a) proposal for an anthropology of public culture. Strangely absent in this literature are the public schools, the font for enculturation into the sciences. Schools are the locus for the formal introduction into our culture's official reading practices of nature.[1] The absence is notable since science's place within the curriculum of schools is such a visible marker of "its" official status. Yet, except as a minor player in larger research projects, we have focused almost no attention on these locations. What is involved in bringing schools in from the cold? What must we do to take schools seriously, as seriously as we have treated laboratories, hospitals, reading groups, universities, informal communities, tourism, advertising, governmental agencies, etc., as places involved in the active production of science/knowledge?

Granted, schools have not been *entirely* absent from our discourses; from Kuhn forward they have played the role of supporting players to the laboratory's lead. Kuhn (1970a) claimed that the role of the textbook distinguished science

[1]By a reading practice I mean to imply both the processes which a cultural group uses to get "correct" readings as well as the processes that turn certain objects into the readable.

from other fields. First, Kuhn noted, that scientists, more than their colleagues in the humanities and social sciences, were dependent on textbooks rather than original sources for most of their training; second, that there was little disagreement between textbooks about what knowledge needed to be covered; and third, that there was no serious discussion of current controversies within textbooks. “Even books that compete for adoption in a single science course differ mainly in level and pedagogic detail, not in substance or conceptual structure” (p. 359). Rather than contemporary problems or discussions of current instrumentation, the textbooks emphasized generic sorts of calculations.

> …[T]hese books exhibit, from the very start, concrete problem-solutions that the profession has come to accept as paradigms, and they then ask the student, either with a pencil and paper or in the laboratory , to solve for himself [sic] problems closely modeled in method and substance upon those through which the text has led him. (p. 359)

In Kuhn’s (1970b) terminology, the science textbooks presented an “accretionist” view of science: the view that science proceeds by adding universal fact upon fact paving the way towards Truth.

Where attention has focused on schools, the image has been primarily negative or one of passivity, à la Kuhn’s uncontroversial textbooks. Toumey (1996b), for instance, has written recently that

> Although [science teaching] has had highlights, cycles of reform, and moments of optimism in its history, each generation of public school teachers faces the same timeless obstacles. One is that the content of the science curriculum answers more to the parochial standards of local and state school boards than to the judgments of the scientific community. Another is that science is expensive to teach, both in time and equipment. Superficial science education, based on textbooks and lectures, is far more

> affordable than substantive learning anchored in the many activities of discovery… If science education is the gateway to an understanding of the scientific research ethos, then that ethos is poorly served. (p. 24)

Science education in his light is “timeless” and “superficial” based “on textbooks and lectures.” With exceptions, including other work by Toumey (e.g., 1994), schools have fairly consistently been viewed in our field as static, consensus based, free of conflict, and ultimately banal and uninteresting. Education has been seen as the inverted image of science as a practice: the latter being cast as significant, conflictual, nothing short of a rhetorical battle field (Latour, 1987) and locally determined. Science education, on the other hand, is usually seen as science ready-made, the textbook as serving as a public monument to Kuhn’s normal science (Kuhn, 1970b).

Putting aside whether or not this image of science education is justified until the third section, it should be clear that this narrative of science education as passive, rigid, shallow, normal (in Kuhn’s sense of the word) has served as a rhetorical “Other” to what is “really” interesting in science studies. (Haraway (1997) notes lucidly that in science studies textbooks and pedagogy have a status “way below knockout mice and the top quark…” [p. 103]) Unexotic, in fact ubiquitous, perhaps too familiar to all of us, our own conflicts either reduced in memory or perhaps too painfully evoked, public education is forsaken for sexier cultural terrain. There is also a gender politics that worries me about the treatment of schools in the literature on science and culture. Their portrayal as passive, universal, and ahistorical bears an uncomfortable semiotic resemblance to the signifier of Woman, a mark that stigmatizes most of the workers who labor in these sites (Apple, 1986).

My intention in this paper is to outline the project of understanding science education as a critical point of meaning making about ourselves and nature. This means significant as labs, television, advertising, etc., in our understanding of science as culture. To do this I briefly discuss five dimensions of such a task. First, I argue that we need to focus our attention on the whole intersection of science and education. This is a much broader subject than just science education, per se, i.e. biology, geology, chemistry, and physics. Science also plays critical roles in educational theory in all subject areas, in the architecture of schools, in the ways that children are conceptualized, and in how problems are defined and solved in schools.

Second, I argue that such an anthropology must be dedicated to shaking off images of schooling and science education as static and rethink them as contested fields, both at the level of curriculum and classroom practice. Furthermore, I will point out that at stake in these struggles are concepts extremely dear to us: science as god trick or situated voice/vision; nature as object, actant, or actor (Haraway, 1991c). It is not in labs or anthropology departments only that this cultural work is done.

Third, I will argue that science education as enculturation works not only at the level of contest, but at more subtle levels which are, for all their lack of conflict, just as dynamic. To be active, constructed, or productive includes more than agonistic interaction. Science education is the locus for complex social rehearsals and rituals that locate us in technoscientific culture. Science as culture is about much more than the “scientific research ethos” that Toumey desires to be the heart of science education. It is about our relationship to specialists who seem to ventriloquate nature, it is about the validity and creation of these specializations themselves, it is about an ongoing conversation about nature and the natural, it is about an ordering of our senses (Classen, 1993), and it is about doxa (Bourdieu, 1978/1972), those taken for granted practices that exist as the only possibility for our daily action.

Fourth, I will argue that our studies of science and education need to be sensitive to the local variations of practice. In other words science in education should be understood as local and dependent on particular discursive and material ecologies, just as laboratories are (Rouse, 1993). Even with the general acceptance of national standards (National Research Council, 1996), local practices are highly variable. Science Education as a general object is as mythic as Science writ large, without reference to particular persons, techniques, technologies, or locations. By viewing science education as having this local property the way is also cleared for comparative intra and international ethnographic research.

Finally, I will argue that it is not enough to simply study systems of science as they are. Our research should see itself as partisan in struggles to make education better: more sophisticated and just. To start with, our narratives and metanarratives of scientific work are too pregnant with consequences not to have a bearing on the work of science teachers. As will be argued later, the vision of science we have produced has consequences for everything from the structuring of the school day, to the science curriculum, to the daily pedagogical practices of teachers. More specifically the study of science and education should see itself as part of re-imagining what the link between these two signifiers (science and education) might be.[2]

1. Locating the Intersection of Science and Education

To begin to understand how education becomes a critical point in science and culture, it is important to understand how science and education meet. Obviously formal science education is one critical part of this intersection, but it does not stand alone. It is one institutionalized node in a complex set of other nodes connecting locations (e.g., state and national governments, organizations of

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[2]For a general discussion of how cultural studies of science imagines both its research methodology and science specifically see Rouse (1993).

teachers, scientists, and parents, publishers, school districts, and church groups) both within and outside the institution of formal schooling. It is tempting, however, to treat science education as a practice disconnected from the rest of schooling or the rest of science. Focusing on science classrooms or on science education policy without understanding the complex—often fractal—connections between schools as institutions and science education, however, would miss the context for much of the particular shape that science education takes as a pedagogic discourse (Bernstein, 1990).

Science education in its present form in the U.S. arose with modern schooling. Scott Montgomery (1994) describes four tangled threads which enabled science at various levels to be integrated into the school curriculum: (1) the inverting of the classic hierarchy of the humanities over the sciences; (2) the conceptualization of science as regularity and, therefore, regulation, (3) the application of this vision of regularity, first, to the child and her/his growth as an object of study and, (4) second, to the curriculum and schools as a way of managing this growth. Schools are part of a web of technologies created in the 19th century designed to scientifically manage childhood; a web which included Freudian and Piagetian psychologies, and pediatrics along with pedagogy.

For most of the 19th century, the sciences played a minor role in both higher and secondary education, to the extent that the latter even existed. The emphasis was literature and classical languages. The curriculum was driven by the model of the liberal arts which were liberal in that they attempted to liberate the student from practical need.

> ...science was long given a reduced importance... within the limits of this tradition. The reason for this is fairly straightforward. The ideal individual, encoded within the “liberal arts” curriculum, was someone who demonstrated maximum powers vis-à-vis language, its forms and uses, both

> written and verbal; such after all, was the substance of leadership at the time in art and politics. With the exception of natural philosophy, science did not fit well into this paradigm because it was linked with the "practical arts." (Montgomery, 1994, p. 23)

The reversal of this hierarchy happened rapidly in the three decades following the civil war, according to Montgomery. It was a change that was highly overdetermined. In part, it was facilitated by redefinition of the work of science from a focus on the practical and natural to the laboratory and the theoretical, e.g., Darwin's theory of evolution; or Kelvin's theory of thermodynamics. This level of abstraction mirrored the transcendent quality of the liberal arts and permitted the sciences to enter the curriculum in a form compatible to the liberal arts. Second, from the link between science and engineering and the transformation it, i.e., that link, generated in the industrialization of the U.S., there arose a popular faith in scientific knowledge and the connection between technoscience and the health of the nation state.[3] Finally, a perceived racial chaos associated with immigration and urbanization encouraged the bourgeoisie to turn to science as a source of stability.

For these and other reasons, science became the center of all but one strand of education reform efforts at the turn of the century. Herb Kliebard argues that four ideologies contested for control of the curriculum in schools: classical humanists (those defending the liberal arts), developmentalists (those who argued that curriculum should derive from the study of children), those who shaped schools for social efficiency, and finally, social meliorists, who saw in schools a means for social justice and societal reconstruction. Each of these (with the exception of the humanists) saw their approach as deeply scientific, and their

[3]This nationalist science contrasted with the postrevolutionary bond between science and nation which focused on the personal connection to the landscape and its flora and fauna (Montgomery, 1994, p. 43).

differing views of science show how science itself was an open signifier (Kliebard, 1986, p. 89). For the developmentalists science provided both an evolutionary notion of proper development and a technique for understanding that development: child study. Dewey, the most famous of the social meliorists, “idealized” scientific inquiry as a “general model of reflective thinking” (p. 89).[4] Finally, the social efficiency reformers claimed, with more success than the other groups, that they had proper claim to the signifier “science” with their interest in “exact measurement and precise standards in the interest of maintaining a predictable and orderly world” (p. 89).

The science of both the developmentalists and the social efficiency reformers was influenced by German romanticism, which was centrally concerned with decadence and degeneracy. For the developmentalists this was expressed as a concern with natural development.[5] This developmental model was based on Haekle’s idea that “ontogeny recapitulate phylogeny.” But for the developmentalists this meant not just biological ontogeny, but social as well.

> To understand the child or the race we must constantly refer to the other... The child relives the history of the race in his acts... The all-dominant but of course mainly unconscious, will of the child is to relive this past, as if his early ancestors were struggling in his soul and body to make their influences felt and their voice heard. (Hall cited in Kliebard, 1986, p. 45)

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[4]This remained a central part of marxist belief. Althusser, for instance, saw science as the only avenue to escape ideology (Althusser, 1971; de Lauretis, 1987; Young, 1992).

[5]Stanley Hall, a key leader and spokesperson for developmental theory, believed that the reason for studying children was to craft a curriculum that would slot each child into their social place. Even this idea has recurred recently in the work of Howard Gardener whose seven intelligences owes much to the field of developmental theory (1987). In a way, the humanists, while validating only elite knoweldge, were relatively egalitarian in believing that all children could and should master it, and that schools should not be responsible for slotting children into the social machinery.

Even though "race" here may have referred to a general human race, rather than the Aryan race, a hierarchy of kinds was clearly present in the idea of developing civilizations, i.e., Europe/America on top and Africa on the bottom (for more on the implied racism and colonialism of developmental theory see Bailey, 1993). Ross, founder of the social efficiency movement[6], was far less subtle. According to Kliebard, he "could scarcely conceal his admiration for 'the restless, striving, doing Aryan, with his personal ambition, his lust for power, his longing to wreak himself, his willingness to turn the world upside down to get the fame or the fortune, or the woman he wants,' especially when compared to 'the docile Slav or the quiescent Hindoo.'" Schools for Ross were part of a system to control the effects of modern industrial society, and specifically capitalism, which threatened to corrupt these "Teutonic" instincts (cited in Kliebard, p. 91).

Modern schools were largely shaped through the negotiations of these two groups—though social meliorists and humanists have left their distinct mark—as a defense against the social decadence they both feared. Seen in this light schools must be understood in the context of similar institutions such as natural history museums, where, as Haraway (1989) has noted, conservation, preservation (i.e., taxidermy), and eugenics came together to barricade against these same threats.

Science education (unlike the humanities which predated this retooled education and could be understood as contesting the scientific vision) was part and parcel of this machinery of social prophylaxis. There were many roles that science education was expected to play in crafting a more rationalized and sanitized society. First, it seemed amenable to helping students slot themselves into their "appropriate" locations in the social machinery: general (practical) science for those

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[6]The social efficiency movement is by far the most influential of the four strands with such current approaches as Outcome Based Education, Madeleine Hunter's Lesson-planning, and the administrative structure of schooling being direct descendents.

destined for the shop floor, abstract science theory as an addition to the humanities curriculum. It was also viewed as specifically helping produce the model citizens for the scientific/rationalized society that these curriculums' crafters envisioned. Biology in particular was imbued with specific moral values. Science had always been credited with encouraging appropriate temperaments. According to Montgomery, in the early republic the sciences were extolled by men like Jefferson and Franklin for "encouraging the betterment of the individual character. Honesty, patience, discipline, observation, civility, and industriousness— 'virtue,' in other words, in all its Protestant forms…" (p. 18) At the time of modern schooling

> …biology was used to teach an organic morality essential to a good and proper social existence... Political/moral contents for the making of a "better citizen" could be legitimized by being brought within the realm of the "scientific" itself: to be tidy and well-groomed, to observe proper dietary habits, to sanctify life, and to be restrained in sexual matters—these and other middle class values were all taught as being "part of nature," necessary elements in "the order of life on earth." (Montgomery, 1994, p. 148)

Science education was part of the technology for producing/maintaining a social order. From its very beginnings it was a moral and social discipline. In New York City, for instance, biology came to be originally introduced into high schools as a result of a specific law "sponsored by the Woman's Christian Temperance Union, that required every ninth-grade student to devote ten weeks of the school year to the study of 'physiology and hygiene with special reference to the effects of alcoholic drinks and other narcotics'" (Pauly, 1991, p. 666).

The women's temperance movement, race/blood theory, industrial rationalization, social Darwinism, scientific Marxism: science education is a locus where all these differently interested, highly political, and often contradictory social movements have and in some ghost like form, continue to contend and negotiate.

To read science classrooms through a critical social anthropology, therefore, we need to look beyond both the classroom and the subject area, just as another generation of anthropological work on science had to look outside the laboratory (Latour, 1983). Science classrooms are intricately tied to and shaped by multiple often competing enclosing and exterior institutions. This complexity requires a reading practice, a process of selection, that attends both to the context of schools, and schools in the context of the social struggles in which they are (re)created. In other words, like other loci in the web of technoscientific culture, we must learn to see school science as heterogeneous and open, a place where multiple interests are articulated (Haraway, 1991a; Rouse, 1993).

To help remind us of the problematic nature of the boundary between science education and education as a science, I will refer to the object of study, the entire region where science and education meet, by the initials SE. Designed specifically to confuse insides and outsides of the science classroom, SE implodes such referents as science education, scientific education (i.e., the science of education), and speculative education (i.e., what schools and science education have the potential to be).[7]

2. SE as a Contested Field

To counteract the image of both SE and science education as static, conservative, "parochial" institutions, it is important to understand the ubiquity of

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[7]This ploy of renaming as a way of confusing boundaries I have liberally poached from Haraway (1989). Crossing boundaries of fiction, history, film theory to read the multiple sites producing the discourses of primatology, Haraway suggests that she is writing in a blurred genre called SF:

> Judith Merril idiosyncratically began using the signifier SF to designate a complex emerging narrative field in which boundaries between science fiction (conventionally, sf) and fantasy became highly permeable in confusing ways, commercially and linguistically. Her designation, SF, came to be widely adopted [in a] ... proliferation of "sf" phrases: speculative fiction, science fiction, science fantasy, speculative futures, speculative fabulation. (p. 5)

My variation on this, what I call SE, refers less to my use of multiple disciplines than to the ambiguity of the subject itself.

struggle that happens in this domain. Schools are hot with conflict. The levels of struggle in which science is evoked either to justify a position or as the terrain of struggle itself include fights over the purposes of schooling, the meaning of childhood, the purposes of the science curriculum, particular issues within the science curriculum, and finally the daily fights over obedience between teachers and students.

The first two levels of struggle were detailed in the last section. As I noted there, schools were shaped by the conflict between humanists, developmentalists, social efficiency advocates, and social meliorists. These struggles also reflected differences over the meaning of science itself. Schools are still the site of philosophical struggles including over the meaning of science (inquiry or control, for instance), though now these struggles are voiced using discourses of outcomes based education, multiculturalism, reader response theory, cross-disciplinary work, and standardized testing. More briefly, the last section also noted that childhood itself, i.e., through the work of Hall and other child study advocates, became a technical/scientific object in those struggles. Schools through the sorting, measuring and grouping of students have become ways of institutionalizing scientific notions of normal childhood.

Like schooling in general, the overall purpose of science education specifically is open to multiple interpretations. Donahue (1993) has chronicled the struggles between groups over the physics curriculum between the 1930's when social meliorist ideas first started impacting the discipline through 1950's when the elitist and abstract curriculum of the Physical Science Study Committee (PSSC) achieved a sort of hegemony in the wake of Sputnik. On the one side were teachers inspired by post-Deweyan pragmatism for whom physics was its application to pedestrian phenomena and technologies of life (vacuum cleaners, airplanes, etc.). On the other was the government backed PSSC, who were vociferously opposed to "life adjustment" curricula and for whom physics was equated with its more esoteric phenomena and discoveries, i.e., post-Newtonian physics—nuclear phenomena, quantum theory, thermodynamics, etc. (p. 341).

In biology, the curriculum itself could be seen as part of a class struggle that, through its connections with Dewey, was also part of the struggle of the four groups listed in the last section. (social melorists, etc.) On the one hand there were groups like the Women's Temperance Movement that wanted a curriculum to promote temperance and other middle class habits regarding the body and sanitation for new immigrants. On the other side, as detailed in Philip Pauly's study of the beginning of formal biology education in the New York City school system at DeWitt Central High School in Manhattan in the early 1900's, were teachers with more radical agendas and administrators concerned with organizational efficiency. DeWitt Central's first two biology department chairs were open leftists closely connected to Dewey, who was then at Columbia University. These teachers authored the most popular textbooks of their day, books which focused on the "explicitly urban problems of nutrition, ventilation, and sanitation." One member of the DeWitt faculty, Gruenberg, discussed in his text the need for dust-free factories (p. 677), a fairly overt attempt at making science education a tool for a more equitable future for his working class students.[8]

In addition to questions of for whom and to what ends the science education curriculum should serve, there have always been deep struggles over

[8]The very inclusion of the sciences within the school curriculum represents a partial victory by rising sectors of the middle class. The older humanities curriculum, patterned after European education, was predicated on an aristocratic elitism. Focusing on classic texts, Greek, and Latin, It was designed to promote timeless verities and was explicitly afraid of practical knowledge. As such, it embodied the cultural capital of the ruling male elite. Science, by contrast, was seen as practical and very worldly, tolerable as a gentlemanly hobby, but not suitable for education. As both Pauly and Montgomery note, science education had to pattern itself after this elitism, in part, to be accepted in schools. Nevertheless, the introduction of science into the curriculum can also be read as a response from "below" for the type of knowledge that might apply to daily life.

particular practices and themes within the science curriculum. The most famous of these is, of course, the struggle over evolution. Toumey (1994) has chronicled the struggles between creationists, school boards, and universities in North Carolina, and how these groups have negotiated a peace worked between themselves. Again, more is at stake in these struggles than just the particulars of biology curriculum. These groups are also struggling over whether science should be about finding G/d's handiwork on Earth or about a secular conversation with nature.

But Pauly notes that creationism is only one of many hot spots in the biology curriculum. For instance, debates over vivisection, dissection and animal rights has from the very onset plagued biology education (Pauly, 1991, p. 680).[9] The question of dissection and vivisection was from the outset gendered: "vulgar boyish cruelty toward animals" on the one hand, and "effeminate sentimentality about nature" on the other (p. 681). Yet this debate articulates in multiple ways with the formation of the modest witness of experimental, scientific truth. Haraway (1997), citing Elizabeth Potter, notes that women threatened this act of witnessing.

> …Potter recounts a demonstration attended by high-born women at which small birds were suffocated by the evacuation of the chamber in which the animals were held. The ladies interrupted the experiments by demanding that air be let in to rescue a struggling bird. Boyle reported that to avoid such difficulties the men later assembled at night to conduct the procedure and attest to the results. (pp. 31-32)

These issues of proper witnessing have not been resolved. They got recent air play in an episode of Rosanne in which the older daughter, Becky, chose to receive a

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[9]In a reversal of the usual assumption that secondary science education lags far behind lab science, Pauly notes that plant physiology received a huge boost from the debates over vivisection in high schools.

lower grade in biology rather than participate in dissection. What is at stake here and in other struggles over SE is not only what knowledge counts, but what counts as a procedures of truth production.[10]

Student resistance to education constitutes yet another level of struggle over the heart of science education and SE generally. It has long been acknowledged that such resistance is a political act connected to differences of class, gender, race, and age. (Apple, 1982; Ellsworth, 1989; Giroux, 1983; Willis, 1977) What has not been acknowledged is that the power that students resist is predicated on theories of science as they constitute child centered, teacher centered, and even "liberatory" educational practice. In other words, students are contesting notions of science when they resist. Such struggles are perhaps the most difficult for us to track, in as much as the explicit discourse of both students and teachers dealing with "discipline problems" may seem not to deal with science at all.

To see science education as a passive, stagnant domain is the result of a theorizing effect (Bourdieu, 1978/1972), the consequence of not being implicated in the battles that happen every year and every day in science classrooms. Rather than the drab image of a frozen institution always looking backwards, schools are places where contemporary epistemological and political struggles are carried out by and through teachers and students.

3. Science Education as Ritual and as Doxa

To reduce cultural production to agonistic encounter is, however, to make a metonymic mistake. While struggle is interesting, perhaps because of its role in our narrative structures or perhaps because of its existential effects, much of any

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[10]A more recent struggle to emerge in biology education is over environmental education. Several authors (Gamoran & Weinstein, forthcoming; Weinstein, 1997b) backed by corporate money or through conservative think tanks have charged that such curriculum are explicitly anti-corporate.

cultural system is about ideology, ritual, category formation, habitus (bodily dispositions) and doxa (the taken for granted, that for which no alternatives exist. Cf. Bourdieu, 1978/1972). It is not that struggle plays no part in these aspects of culture, but that such struggle is incidental in the overall processes of cultural production.

One important aspect of this non-agonistic side of science education as culture is the promotion of a certain authority structure. A central, yet never explicit, message of most science curricula until very recently, whether in the progressivist or disciplinary traditions, is that science alone, and thereby scientists alone, speak for nature. In short the curriculum tends to promote a deferral to authority and does so consistently from kindergarten through the end of undergraduate education.

At the primary and elementary end this structure is established through a structure of feeling (Williams 1977), i.e., an association of nature/science with a state of wonder. Wonder here refers to a state of epistemological openness, a prejudgemental state, one which can be colonized for various interests (Greenblatt, 1991). The rhetoric of science as wonder is consistently presented in schools, television, museums, and books. Elsewhere I have argued that wonder is evoked, sometimes quite explicitly and in the most militaristic language, so that they are dazzled into loving the science/nature connection (Weinstein 1995; Weinstein 1997/forthcoming). A common technique/rhetorical form used to accomplish this is the magic trick (Weinstein, 1997a). In the state of awe that the trick produces in students, science (as an undifferentiated and uncontradictory dogma) can claim for itself authority without contest. The effect is to make nature seem to be magically produced by science and therefore scientists (Haraway (1997, p. 103) takes this one step further noting that this production of nature can then be turned around and used to justify the social, i.e., capitalism, bureaucracy, etc.).

At the college level this same authority is accomplished through direct intimidation. Sharon Traweek in her study of the life cycle of physicists (1988) notes that undergraduate physics texts acknowledge only the immediate past which is embodied in the work of immediate predecessors "who can be labeled the heroic discoverers of current, supposedly correct, scientific ideas" (p. 77). The student, however, is not to identify with this hero, but be in awe of him (gender intentional). "…[S]tudents are urged to assume that they are not going to be an Einstein or Dirac, but merely soldiers in the ranks who must learn the established rules for puzzle solving within the existing theories… According to [the quantum physics] text, the gap between the students and the heroes identified in the margins is quite large" (p. 80). The authority of science is not, in these examples, established by force and, thus, marks a key example of the sort of non-agonistic cultural feature with which I am concerned.

A related ideological dimension of science education concerns the unity of that authoritative voice. Michael Apple (1990, p. 89) has called this the consensus theory of science which "underemphasizes the serious disagreements over methodology, goals, and other elements that make up the paradigms of activity of scientists." As was noted in the introduction, textbooks do not present controversies—except as just-so stories for the current dogma (Kuhn, 1970a). Whether the textbook works through hands on experimentation, constructivist confessions of one's misconceptions, or through rote procedures, the cosmology remains the same.

Beyond establishing the social power of scientists to speak for nature, however, schools also introduce to their students a complex set of distinctions and relationships that constitute the social and the natural. For instance, Mary Atwater (1995) reports that the science curriculum critically establishes the categories of animate and inanimate, a distinction which some Native American communities reject.

The reading into nature of categories (genus, species; energy, matter; etc.) also works outside the science classroom, again reminding us that the proper object of our study should not be science education (door closed), but SE, an ambiguously open apparatus of subject production. The sorting of animals into clads {???} or evolutionary trees and children first into developmental levels and later into learning disabilities is part and parcel of a science that cannot distinguish logics of discovery and adventure from socio-natural control (Apple, 1990, p. 126).[11]

More indirect has been the way that the biology curriculum circulates notions of pollution and cleanliness. Mary Douglas has noted that dirt and pollution are “social” categories and that the act of separating the clean from the unclean is a crucial part of identity/cultural production. Thus discussions in biology on such topics as sterility, cleanliness, disease, poison, and contamination are as much about cultural practice as about an extra-human nature. Furthermore, in as much as these discourses involve the immune system, they are also cultural tales of self and other (Haraway, 1991a; Martin, 1994; Treichler, 1987), ways of distinguishing the valuable from invaluable (through notions of flexibility in Martin’s account for instance) and the quality of the line between self and other (strong or weak, militarized or dialogical).

Finally, science education, or rather SE, produces bodily dispositions (habitus) in ways that are not particularly conflictual, yet no less potent or interesting. Of course, biology generates explicit discourses of the body (Martin,

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[11]While there is some level of contestation over the practice of sorting “exceptional children” (Coles, 1987; Sapon-Shevin, 1989; Sapon-Shevin, 1994), it is overwhelmingly accepted by people both labeling and being labeled.

1987; Martin, 1994; Penley & Ross, 1991; Strathern, 1988), which science education introduces as a cultural common place. (Though even here there are counter discourses as demonstrated in Davis-Floyd's (1992) accounts of women choosing natural childbirth and Martin's (1990) studies of working class womens' narratives of their own bodies.) As a more subtle example of the ways that the sciences and science educations shape the body, consider how the senses become differentially valued in scientific practice. In short, visual evidence ranks higher than other sense data (Ackerman, 1990; Classen, 1993; Tyler, 1987). This opticentrism is reflected in hight school textbooks through the use of photos (often computer enhanced) as self-evidential proof, i.e., with no accounting for the production of those images. This hierarchizing of the senses has had a profound impact in everthing from horticulture to medicine (Classen, 1993). Science education becomes a locus for students to naturalize this hierarcy (for a more detailed analysis of opticentrism in a biology textbook see Weinstein, 1995, Chapter 2).

SE is thus the locus of many—I have not attempted to be comprehensive here—culture shaping practices. These practices arise both through and within conflict as well as in less dramatic moments. Students rehearse in their daily work deference to anonymous authority, shape their bodies in certain ways, and practice substantiating complex sets of categories both about others and themselves.

4. Multiplicity and the Production of Science Education

I argued earlier that classrooms have complex connections to other locations in the network of science as culture. In acknowledging the connections between schools and other locations, I am not claiming that there are not important features which distinguish SE from other nodes in the technoscientific network. In this section I will briefly explore two differentiating aspects that are critical to an anthropology of science in education. The first concerns the processes which distinguish SE from other nodes in the technoscientific culture. The second concerns the need to resist homogenizing schools as a monolith.

A. Differences I: The Particularity of SE

Most critiques of science education, regardless of political sentiment, condemn science education for not mirroring or representing the way science really is (e.g., Gough, 1992; National Research Council, 1996; Roth, In Press). The assumption behind these critiques is, of course, that science is elsewhere, not in schools. It is a metaphor-metonymy confusion. SE is part of the cyborg[12] of science, not an exterior point which can mirror back science's "true" nature. Even if this inside/outside problem were not an issue, however, schools could not mirror laboratory science. The impossibility of this is due to the different material and discursive pressures that schools vs. labs/research institutions face. Different locations are invested radically different sorts of struggles: labs in getting nature to speak, schools in getting students to understand; scientists are driven by their love of nature and/or research, fear of unemployment, the pressure of funders, etc., students by fear of failure, need for the approval of their teachers, peers (which may work to encourage or discourage them), and parents. Teachers too face multiple set of drives/loves (of children, nature, etc.) and demands from parents, principals, students, their peers, teachers in subsequent courses who will expect subject matter coverage, overcoming student indifference, etc. In answer to such pressures these differently situated actors are likely to adopt conventional and historically developed responses. As a result these locations can never equate. Student labs cannot look like professional labs since, to use a game metaphor, the boards on which they are played are radically different.

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[12]How do we visual institutions? As bodies, using organic metaphors like Hall? As machines, like Bobbitt and others working in Ross's footsteps? Can we use a betwixt and between metaphor as a marker of our discontent with our language?

Basil Bernstein has gone far in providing a general model for the transformation of knowledge as it moves from one node to another (Bernstein, 1990). The discourse shaped by the interests of schooling he calls pedagogic discourse.

> Pedagogic discourse, then, is a principle which removes (delocates) a discourse from its substantive practice and context, and relocates that discourse according to its own principle of selective reordering and focusing. In this process of delocation and the relocation of the original discourse the social basis of its practice, including its power relations, is removed. In the process of the de- and relocation the original discourse is subject to a transformation which transforms it from an actual practice to a virtual or imaginary practice. (p. 184)

Bernstein cites three transformations that occur to a discourse (or text) in the process of being brought into schools:

> 1. The text has changed its position in relation to other texts, practices, and position.
> 2. The text itself has been modified by selection, simplification, condensation, and elaboration.
> 3. The text has been repositioned and refocused. (p. 192)

This happens at two levels, however. First, it happens in the construction of curriculum materials, such as textbooks, lab kits, etc. Second, it happens in the reading practices of both teachers and their students as they reinterpret those materials, i.e., in their own reading practices.

It is easy to blame schools for this transformation. Science as it lives in the lab, however, is necessarily dependent on a specific set of social, material, and institutional conditions to keep it in shape. Without the formal review of peers, the informal review of co-workers, the pressure of publication, etc., the facts and practices produced will morph rapidly to meet the conditions of a new ecology of knowledge.

To return to those who hunger after an adequate representation of the real in schooling, science education will never satisfy—which is not to say that science education need be superficial. The actors involved in classrooms, however, face a different set of circumstances and thus will translate science as it grows in the lab into something else.

B. Differences II: The Multiplicity in SE

What that something else is, however, is highly variable. In the last section, I suggested some forces or interests which shape the knowledge produced in schools, e.g., peer judgments. There is nothing deterministic about these forces. To use the sports metaphors favored by Bourdieu (1990), there is a world of difference between knowing how chess pieces move and playing a competent game of chess. Similarly, neither knowing the rules nor being able to play a game will allow one to predict how any particular game will proceed in advance. The rules of the game enable as much as limit possibilities for improvisation, interpretation, and variation in schools. What happens in science education depends greatly on where students and teachers find themselves located in the deadly games of tracking, gender, race, class, and geography (etc.).

The methodological moral here is that “the particular exceeds the general quite as much as the general exceeds the particular” (Strathern, 1991, p. 285). Close readings, ethnographic readings, of classrooms, schools, school boards, policy fora, state legislatures, all the locations that make up SE, are needed to understand how science (education) as culture is a lived culture. It is only at this level that we see a science education that is substantially different from the relatively timeless or cyclical picture of the mythical norm that emerges in studies of policy and discourse, e.g., Kliebard’s or Montgomery’s histories. It is also at this level that we can see how science education intersects with struggles over class, race, postcolonialism and gender, as in Ndunda and Munby's (1991) study of girls' visions of science and their futures in two high schools in Nairobi, Kenya. Again, it is at this level that we can see how science education becomes the occasion for struggles over situated knowledge, as in Angela Barton's account of a 6th grade, homeless student of hers confronting a gas station owner over whether her nose smelling gas fumes was more or less valid than EPA's certification process (Calabrese Barton & Osborne, 1997).

Joseph Rouse (1993, p. 11) has written that "Scientific knowledge is often discussed as if it were a body of free-floating ideas detachable from the material and instrumental practices through which they were established and connected to things." Science education frequently takes on that same disembodied, undifferentiated appearance in discussions. Studies of textbooks substitute for lived readings of those texts; policies are read as though they were life in classrooms. A focus on particulars, on the multiple ways that science educations can play out, and on the discursive and material conditions that result in a variety of classes and schools are needed to help us understand what this portion of the technoscientific terrain feels like and to help us act responsibly within and towards "it."

5. Intervening in SE

By studying schools, we also become participants in those places. (Roman & Apple, 1990) Anthropologists offer much that could alter substantially the look and feel of science education not to mention SE. As a community we have challenged the borders that seemed to separate labs, museums, television, schools, hospitals, homes, and legislatures. Our works have both tried to represent and intervene in new definitions of nature (Robertson, Mash, Tickner, Bird, Curtis, & Putnam, 1996), the body (Haraway, 1991b), technology (Conley, 1993; Hakken & Andrews, 1993), place (Stone, 1994), and institution (Latour, 1987). Certainly, these frameworks and findings have implications for how students might be thinking about the world. We must be responsible, however, in our interventions.

Responsibility means working with, not against, sympathetic efforts at reform. For instance, feminist and feminist-friendly educators have been trying to use science as the context for Freirian (1968) liberatory practices (Calabrese Barton & Osborne, 1997; King & Ahlquist, 1990; Susskind & Finkel, 1995). In this work, a topic such as ecology becomes a generative theme, a touch point through which students explore the entire technical-social system. From this theme in science they then work to contest/gain some social power, e.g., through demanding action in not-in-my-back-yard local struggles. While these curricula have generally left science as a cultural production unexplored, they do connect science and the public sphere, and encourage students to use science to tell different sorts of stories about their life possibilities.

More explicitly interested in science as a social process are the various science, technology and society (STS) curricula (Solomon & Aikenhead, 1994; Yager, 1996) that have been produced for some 15 or more years, and which have even gained some legitimacy in the recently published science standards (National Research Council, 1996, standards F and G).[13] While most examples of STS in the U.S. context focus on headline making controversies such as cloning and other reproductive technologies, environmental issues, and militarism, there are more substantive exceptions. Jennifer Helms (1995), for instance, has been arguing for and working on science education curricula which have as their primary goal the problematizing science as an epistemological and cultural system.

[13]This inclusion reflects less the Standard's commitment to STS, than the document's role as a slogan system (Komisar & McClellan, 1961) supporting almost every reform under the sun. For a brief critique see Montgomery (1994, pp. 263-4).

One thing we might contribute to these efforts are curricula that explore how science works as a cultural system. This could include, for instance, having students explore the idea that the meaning of science depends on where one is located in the technoscientific culture, in other words, upon which side of the microscope one stands. Students could explore this through imaginative writings about what a bug literally sees and feels while it is being observed or could interview patients and doctors to understand the situated nature of medical knowledge. Similarly the opticentrism of science could be explored through having students try to write up their labs without reference to either visual data or visual metaphors. The role of social negotiation in science and even of power, here embodied by the grading system and the teacher, could be explored by examining transcripts of their own conversations doing lab work.

While most curricula position students as would-be scientists or would-be consumer/citizens, our curricula could offer students the possibility of "playing" anthropologists of science. They could observe in labs; record the distinctions that their textbooks and television programs make. In other words, science education could be an exploration of science as culture rather than being the occasion to celebrate the magician who produces nature. (For a much more detailed description of how cultural studies might affect science education see Weinstein, 1996)

There is another level of SE where our research has implications, however, and that is at the level of the schools themselves. Schools are reified concretions from struggles over the meaning of science: Hall's developmental theory, Ross's social control, and Dewey's social reconstruction. Anthropologists and their friends: Traweek, Latour, Haraway, Penley, Heath, etc., have radically revised these earlier understandings of science as culture, and our new vision (Latour, 1987; Traweek, 1996) of science as an extended network, objectivity as situated knowledge, theory as a story telling practice, and issues of power/equity saturating every aspect of the scientific project (rather than a neutral science with positive and negative consequences, the main model in STS) need to be included in that architecture.[14]

In suggesting ways in which we might responsibly participate in attempts to rethink SE, I have avoided critiquing schools for "not getting it right." These ideas are not about mirroring practices from elsewhere, but instead are about creative positioning, imagination, and self-consciously partial representations. This is what Donna Haraway has called diffraction (1997, p. 268), by which I take her to mean that the stories we circulate are less about journalistic "all the truth that's fit to print" and more about practiced possibility, about "stories as means to ways of living" (Haraway, 1989, p. 8). In this context SE signifies "speculative education" as well as the extant visions of control and regularity.

Conclusion: Towards a Critical Anthropology of Science Education

This paper has had two purposes. First, it has presented my concerns about certain representations of schools and science education in the literature on the anthropology of science. Specifically it has argued, first, that criticisms of schools as unchanging ignore variations at the level of real practice and, second, that critiques which charge schools with failing to replicate or represent "real" science accurately ignore the structural factors which make such a replication/representation impossible. My point has not been that science education is unworthy of critique, but that such critique must be responsible, aware of science education as a lively, conflictual, and contradictory cultural field.

My second purpose has been to outline one possible framework for a critical anthropology of science and education. In working out this framework, I have

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[14]I am not sure what this would look like, nor am I sure that our vision, any more than Dewey's will have a lasting place, given the corporate interest in systems of control and regularity.

tried to be true to the methodological and philosophical principles that have emerged in our collective research practices, such as a skepticism of boundary production and an understanding of research as politically engaged (for a more lengthy discussion see Rouse, 1993). I have argued that science education must be read within the larger context of schooling, itself envisioned as scientific, producing a subject of study I call SE. Second, I have argued that it is important to understand SE is an active terrain of conflicting views over appropriate knowledge, social values, etc. Third, I have insisted that cultural production in SE not be reduced to (or equated with) conflict, that in addition to struggle there is the formation of habitus, acceptance of ideology, ritual, and doxa. I then argued that science education must be understood as multiple, materially local practices rather than representable by a mythic norm, and finally, I have argued that this framework and the research it has generated should be seen as being an intervention into science education itself. In summary, this is a framework that begins by acknowledging that "science is culture" (Haraway, 1991a) and pursues science education as a significant cultural production.[15]

[15]All of this is in preparation of a study of the production of SE in Minnesota faithful to this theoretico-methodological standpoint . In particular I am interested in how practice is shaped by actors struggling over schools from diverse locations: from state policy fora, professional organizations, schools of education, and classrooms.

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