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METAMEDIA LITERACY: TRANSFORMING MEANINGS AND MEDIA

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Transforming Theories of Literacy and Society

Literacies are legion. Each one consists of a set of interdependent social practices which link people, media objects, and strategies for meaning-making (Lemke, 1989a; Gee, 1990; Beach & Lundell, this volume). Each is an integral part of a culture and its subcultures. Each plays a role in maintaining and transforming a society because literacies provide essential links between meanings and doings. Literacies are themselves technologies, and they give us the keys to using broader technologies. They also provide a key link between self and society: the means through which we act on, participate in, and become shaped by larger "ecosocial" systems and networks (see examples below and in Lemke, 1993a, 1995b). Literacies are transformed in the dynamics of these larger self-organizing systems, and we -- our own human perceptions, identities, and possibilities -- are transformed along with them.

That, at least, is the Big Picture as I would sketch it today. Let me try to fill in a few of the details that are particularly relevant to our concerns here. The notion of 'literacy' as such seems to me to be too broad to be useful. I don't think we can define it more precisely than as a set of cultural competences for making socially recognizable meanings by the use of particular material technologies. Such a definition hardly distinguishes literacy from competence at cooking or choosing your wardrobe, except for the particular semiotic resources used to make meaning (language vs. the cuisine or fashion system) and the particular material artifacts which mediate this process (vocal sounds or written signs vs. foods, clothes). There was a time perhaps when we could believe that making meaning with language was somehow fundamentally different, or could be treated in isolation from making meaning with visual resources or patterns of bodily action and social interaction. But today our technologies are moving us from the age of 'writing' to an age of 'multimedia authoring' (see the chapters by Purves and Bolter in this volume) in which voice-annotated documents and images, and written text itself, are now merely components of larger meaning-objects. The meanings of words and images, read or heard, seen static or changing, are different because of the contexts in which they appear -- contexts that consist significantly of the other media components. Meanings in multimedia are not fixed and additive (the word-meaning plus the picture-meaning), but multiplicative (word-meaning modified by image-context, image-meaning modified by textual context), making a whole far greater than the simple sum of its parts (see Lemke 1994a, 1997a). Moreover all literacy is multimedia literacy: you can never make meaning with language alone, there must always be a visual or vocal realization of linguistic signs that also carries non-linguistic meaning (e.g. tone of voice, or style of orthography). Signs must have some material reality in order to function as signs, but every material form potentially carries meanings according to more than one code. All semiotics is multimedia semiotics, and all literacy is multimedia literacy.

The European cultural tradition, among others, has long recognized and made use of these multimedia principles even in ordinary printed texts (cf. Olson, 1994; Alpers, 1983; Bellone, 1980; Eisenstein, 1979), whether in manuscript illustration or the use of diagrams in technical writing. But there has been a certain modern 'logocentrism' (Derrida, 1976) that has identified language alone as a reliable medium for logical thought, and written language as the primary medium of, first, authoritative

knowledge, and lately of all higher cognitive capacities (see Olson, 1994 for a reprise of these arguments and Lemke, 1995c for a critique).

If we are required to specify exactly which semiotic resources and which material technologies define a particular literacy, then we have as many literacies as there are multimedia genres (cf. Gee, 1990). These can perhaps be further subdivided (and so the number of functional literacies further multiplied) by considering whether comptence with both the technologies of production and the technologies of use are to be included. When writing required pen and paper or typewriter, and reading required only the book (and maybe your eyeglasses) these distinctions were simple to maintain. But today whether you wish to read hypertext (see Bolter, this volume) or write it, you still need much the same hardware and software technologies, and you need both new authoring skills and new interpretive skills to use them.

Finally, in the spirit of Latour's (1987, 1993) work on 'actor-networks' in the study of technologies in society, we need to count other people as part of the technological ecology of literacy practices. (Latour constructs social networks from both the human and the non-human 'actors' , such as technical artifacts in a social ecology of cultural practices). The network of interactions that renders a text or multimedia object meaningful is not limited to those between the author or user and the object, but must also include those with teachers, peers, and communities of people who embody the practices that make a particular sign-combination meaningful. Isolated from all social interaction, humans do not learn to talk or write. However appealing the ideology of individualism may make the stereotype of the lone writer or reader, the fact that texts and signs are socially meaningful is what gives them their usefulness and makes them possible. What looks like the same text or multimedia genre on paper or on screen is not functionally the same, follows different meaning conventions, and requires different skills for its successful use, when it functions in different social networks for different purposes, as part of different human activities. A literacy is always a literacy in some genre, and it must be defined with respect to the sign systems deployed, the material technologies involved, and the social contexts of production, circulation, and use of the particular genre. We can be literate in the genre of the scientific research report or the genre of the business presentation; in each case the specific literate skills and the relevant communicative communities are very different.

In the study of written language literacy, there is still considerable debate about how important it is that the material signs of writing are relatively more permanent or more evanescent, how they are organized in space and time, and what counts as 'writing' (mathematics? Braille? videotapes of American Sign Language?). Some of these questions remain of interest for particular genres and technologies, but few of them have yet been reconceptualized in the context of the new multimedia technologies (see Harris 1995 and Lemke 1997b).

We also need to reconceptualize the relations between literacies and the societies in which they operate, and the role of people in these larger processes (e.g. Olson 1994, Lemke 1995c). We need to improve our older ways of talking about these phenomena. It is no longer sufficient to imagine that societies are made up of isolated human individuals, tentatively linked by voluntary social contacts, with individual and autonomous 'minds' somehow dissociated from the material world. We can't get by any more thinking that there is just one thing called 'literacy' or that is it simply what individual minds do when confronted with symbols one-at-a-time.

Every time we make meaning by reading a text or interpreting a graph or picture we do so by connecting the symbols at hand to other texts and other images read, heard, seen, or imagined on other occasions (the principle of general intertextuality; cf. Lemke 1985, 1992, 1995a). Which connections we make (what kind and to which other texts and images) is partly individual, but also characteristic of our society and our place in it: our age, gender, economic class, affiliation groups, family traditions, cultures and subcultures.

Literacies are always social: we learn them by participating in social relationships; their conventional forms evolved historically in particular societies; the meanings we make with them always tie us back into the fabric of meanings made by others.

Literacies are legion. Each different register, genre, or discourse formation (Halliday, 1977, 1978; Martin, 1992; Bazerman, 1988, 1994; Foucault, 1969; Lemke, 1995b; Gee, 1990) is the product of some particular subcommunity going about its special business. Being a native speaker, knowing the grammar, checking the dictionary, is not enough to understand the texts of these specialized communities as their members understand them, unless we also know their contexts of use. Broadcast accounts of cricket test matches are mostly incomprehensible to me even with a rudimentary knowledge of terms and rules and an hour or two watching; even when watching a match as I hear the commentary. I'm not sufficiently a member of this community, don't have enough experience, haven't heard enough commentaries, seen enough matches, understood the strategies of the game, the culture of this community. It's no different if you pick up a research article on quantum cosmology or biotechnology development, or a technical report on needed equipment repairs in an electrical generating station, or a Japanese 'manga' comic book. It doesn't matter if the medium is voice or video, diagram or text. What matters is knowing how to make meaning like the natives do.

Literacies cannot be understood as passive receptivities. Making sense with a printed text is a complex and active process of meaning-making not so different from writing the original of that text (say by editing and modifying a previous draft, or cobbling together from sets of notes a final coherent text). Both reading and writing are meaning-making processes of the same kind. They are in no sense 'inverse' to one another (Lemke, 1989a; Harris, 1995). All that's different are the situational affordances: the other human or inanimate players we interact with to make our meanings -- be they writing partners or marks scratched on paper.

It's been a long time since the technologies of literacy were as simple as pen, ink, and paper; and in the era of print, as before, literacy has rarely meant verbal text alone. Many of the genres of literacy, from the popular magazine article to the scientific research report, combine visual images and printed text in ways that make cross-reference between them essential to understanding them as their regular readers and writers do. No technology is an island. Every literate meaning-making practice is interdependent with skills from keyboarding to page-turning, typesetting to bookbinding, copyediting to marketing and distribution (in the case of print technologies). As our technologies become more complex they find themselves situated in larger and longer networks of other technologies and other cultural practices (Latour, 1993).

Publishing yourself on the WorldWideWeb may cut out many of the old print middlemen, human and machine, but in addition to simple writing and typing skills, you need to be able to operate the software and hardware to get your work formatted properly in HTML, loaded on a server, connected to the internet. Someone has to write and update those programs, someone has to design, manufacture, sell, and deliver the hardware, configure it, maintain the network, develop the protocols, offer technical assistance and service. As a universal information processor, the same computer can serve many of these purposes, which makes the process look simpler; but what people have to know to use the computer, and to design and maintain this whole system of practices, becomes far greater, both materially and semiotically. Some people somewhere have to manipulate more different kinds of matter in more different ways. We have to know how to do more different sorts of things (collectively and individually).

Literacies cannot be adequately analyzed just as what individuals do. We must understand them as part of the larger systems of practices that hold a society together, that make it a unit of dynamic self-organization far larger than the individual. In fact, if we think the word society means only people, then we need another term, one that, like ecosystem includes the total environment: machines, buildings, cables, sattelites, bedrock, sewers, farms, insect life, bacteria ... everything with which we

are interdependent in order to be the complex community that we are. We couldn't be the community we are unless we did the things we do, and most of what we do depends not just on the physical and biological properties of all these system partners, but on what they mean to us.

Dynamically, the total system we are talking about, the one within which we need to analyze changes in literacies and technologies, is not of course a system of things at all. It has to be a system of interdependent processes in which these things participate, and which link them, and us, together into a system. Biological and geological processes, human activities and social practices -- regarded as one system of interdependent goings-on: an 'ecosocial' system (Lemke, 1993a, 1995b). Within this system we have to follow out the links and networks of interdependence: which practices where and when are interdependent with which other practices elsewhere and elsewhen. Critical among these processes, insofar as human action matters to the dynamics of the system, are the meaning-making practices by which we humans interpret, evaluate, plan, and cooperate, including our many literacy practices. (The boundary between literacy practices as such and meaning-making, or semiotic signifying practices in general is a fuzzy one. Core literacy practices are usually distinguished by 'code', language, and by 'medium', spatial, visible, and durable. For efforts to deal with the limitations of such definitions, see Harris 1995, Lemke 1997b.)

We no longer have to separate our material technologies so radically as we once did from our 'cognitive strategies'. People-with-bodies participate in activities and practices, such as jointly authoring a multimedia Web document, in which we and our appliances are partners in action; in which who we are and how we act is as much a function of what's at-hand as of what's in-head. This is the powerful new viewpoint on human activity and society that many disciplines today are converging towards, whether they speak of actor-networks (Latour, 1987; Lynch & Woolgar, 1990), situated or social cognition (Lave, 1988; Rogoff, 1990; Hutchins, 1995), ecosocial semiotics (Lemke, 1993a, 1995b), mediated activity (Wertsch, 1991; Engestrom, 1990), or cyborg transgressions (Haraway, 1991; Sofia, 1995; Bryson & deCastell, 1996). Instead of theorizing causal relations from one autonomous domain to another (technologies to literacies, literacies to minds, minds to societies), if we unite all these domains as participants in the myriad subnetworks of an ecosocial system, we can give detailed accounts of their interdependencies and the self-organizing dynamics of this complex system. We need to break down the artificial boundaries we have tried to create between the mental and the material, the individual and the social aspects of people and things interacting physically and semiotically with other people and things.

Today new information technologies are mediating the transformation of our meaning-making communities. We can communicate more often and more intimately with more geographically and culturally diverse communities than ever before. On-line conferences and listserver groups, the denizens of chat rooms, and the pioneers of MUDs and MOOs (Harrison & Stephen, 1996; Unsworth, 1996; Day et al., 1996) are extending old communities and creating new ones (Rheingold, 1993).

People who corresponded a few times a year, and met once or twice at conferences, can now be in regular contact by email, by inexpensive (we hope) voice internet, and perhaps soon, bandwidth and the regulators willing, by video-conferencing. You can have a more significant dialogue with someone in Australia than with someone across the hall, and sustain it just as easily. You can don a new gender or identity, in masquerade or for exploration of possible Selves (Stone, 1991; Day et al., 1996). You can experience new kinds of relationships to people, be treated differently by them. You can 'lurk' and listen in communities you might someday want to join. You can have a first taste without risk or commitment. And you will hear viewpoints expressed which you might not otherwise have come into contact with, or might have discounted prematurely out of prejudice if you identified their source in other ways than what cyberspace makes possible.

Every new community, every transformed community, potentially represents a new literacy. Every new system of conventional practices for meaningful communication already is a new literacy,

embedded in new technologies. All participation in new communities, in new social practices, potentially makes available to us new identities as individuals and new forms of humanity as members of communities. Insofar as education is initiation into communities, and especially into their generic and specialized literacy practices, new information technologies, new communication practices, and new social networks make possible new paradigms for education and learning, and call into question the assumptions on which the older paradigms rest.

Old practices migrate en masse to new or transformed ecosocial systems: we recreate much that is already familiar. Our Web documents initially look like print documents. Our on-line communities initially grow out of familiar institutional groupings. But our new on-line homes come equipped with new appliances, our old practices take on new meanings in these new settings; new opportunities will get taken up, new serendipities become likely. Change and transformation is at work.

Transforming Literacies

What are the new literacies that new information technologies are making both necessary and possible? The generic literacies of the Information Age will certainly include (Lemke, 1996b): multimedia authoring skills, multimedia critical analysis, cyberspace exploration strategies, and cyberspace navigation skills.

But there is also an even more important question to consider. How can we understand what they demand of us, and how can adopting and adapting them transform social relationships and social structures? I will discuss below some larger themes that go beyond specific literacy skills and which I believe will define the most radical transformations in literacy and literacy education which the new technologies may bring.

Multimedia Literacies

Multimedia authoring skills and multimedia critical analysis correspond closely to traditional skills of text-writing and critical reading, but we need to understand how narrowly restrictive our literacy education traditions have been in the past in order to see how much more students will need in the future than we are now giving them. We do not teach students how to integrate even drawings and diagrams into their writing, much less archival photo images, video clips, sound effects, voice audio, music, animation, or more specialized representations (mathematical formulas, graphs and tables, etc.). For such multimedia productions it does not even really make sense any more, if it ever did, to speak of integrating these other media 'into' writing. Text may or may not form the organizing spine of a multimedia work. What we really need to teach, and to understand before we can teach it, is how various literacies, various cultural traditions, combine these different semiotic modalities to make meanings that are more than the sum of what each could mean separately. I have called this 'multiplying meaning' (Lemke 1994a; 1997a) because the options for meanings from each medium cross-multiply in a combinatorial explosion; in multimedia meaning possibilities are not merely additive.

At least this is so in principle. In practice, every multimedia genre, every multimedia literacy tradition, restricts the enormous set of possibilities to only some allowed or favored combinations, but there are still always more than what one would get just by adding those of each medium separately. No text exactly duplicates what a picture means to us: text and picture together are not two ways of saying the same thing; the text means more when juxtaposed with the picture, and so does the picture when set beside the text.

We need also to realize that these multimedia skills are not 'advanced' skills that should only follow learning the separate media literacies. Young children's early modes of communication integrate vocal articulations with large-motor gestures; they only gradually learn to differentiate gestures from drawing, and drawing from writing, as independent systems for making meaning. They are perfectly ready to learn integrated multimedia literacies from the start, and of course they do: they learn to read picture books while talking with adults and playing with toys that resemble images in the books. They begin to write-and-draw while telling stories and leaving traces of their gestures on paper, walls, and refrigerator doors (cf. Hicks & Kanevsky, 1992; Dyson, 1991; Lemke 1994a). But our theories and teaching of literacy have been long been too logocentric. While children are learning to distinguish different semiotic resources (e.g. drawing from writing), thus opening up larger combinatorial spaces for using them in co-ordinated ways, we are only teaching them to use one: written language. When we do teach others modes, such as singing, drawing, or mime, we still do not teach students about the traditions and possibilities for combining these with writing and with each other. That needs to change, very quickly and very thoroughly, if we are to help students develop sophisticated multimedia literacies. Their new authoring skills will hopefully enable students to create multimedia portfolios (cf. Kieffer et al., this volume) that will help teachers remove the logocentric bias from our evaluations of their understanding and competence, as well as enable them to produce the kinds of meanings they really want to mean.

Likewise, critical interpretive skills must be extended from the analysis of print texts to video and film, to newsphotos and advertising images, to statistical charts and tables, and mathematical graphs. We must help students understand exactly how to read the text differently and interpret the image differently because of the presence of the other. We even need to understand how it is that we know which text is relevant to the interpretation of which image, and vice versa. All of this requires, at least for teachers and media specialists, a useful understanding of multimedia semiotics.
I am currently trying to develop such a general theory of multimedia based on seeing how three universal semiotic functions: Presentation (creating or describing a world), Orientation (taking a stance toward the Presentation and its audiences), and Organization (linking parts into wholes) draw on the resources of each available semiotic modality (language, typography, images, music, etc.) to produce a meaning effect (Lemke, 1989b, 1995b, 1997a). For instance representational imagery in painting presents the world, but figure perspective orients the view to it, and the composition of masses and vectors of edges and lines organize its parts into a coherent whole. In text, we present with propositional content, orient with mood (command vs. question) and modality (may vs. must), and organize with genre structure (introduction, body, conclusion) and cohesion (John ... becomes ... he ...).

Other, related work in social semiotics is also contributing to this understanding (e.g. O'Toole, 1990, 1994; Kress & Van Leeuwen, 1996). With such a functionally motivated framework for desribing what is possible in multimedia, it should be possible not only to analyze particular multimedia works, but to compare different approaches and traditions in terms of which possibilities they make use of and which they do not. We may even be able to identify new combinations worth trying out.

Both authoring skills and critical interpretive skills for multimedia potentially transform not just the ways students and teachers communicate information and ideas, but also the ways in which we learn and teach. Kinzer & Risko (this volume) report on ways in which prospective teachers can learn by producing multimedia analyses of their initial teaching experiences. Goldman-Segall (1992) and Tierney & Damarin (this volume) provide analogous case studies of students learning through multimedia production. In both cases the integration of video and pictorial realism, providing context and complexity, with textual analysis, providing focus and conceptualization, help define and transform viewpoints on our own and others' experiences.

Informatic Literacies

The literacies of the Information Age are not just about making and using multimedia. They also include 'informatic literacies': the skills of the library user as well as those of the text user. Skills for categorizing and locating information and multimedia objects and presentations. Cyberspace will be many things: the world's ultimate shopping mall, humanity's most enticing playground, the university of universities, and, especially from a literacy point-of-view, the library of all libraries. Search and retrieval strategies will be subsumed in the arts of exploration and navigation; we will replace a metaphor in which texts come to us (e.g. downloading them from a remote server) with one in which we go to them (navigating though virtual 3D-worlds that represent servers and their contents). What strategies are useful for finding out what kinds of knowledge exist in the world? How do you browse the library of cyberspace? Once you pick an area of interest, how do you systematically explore it? And once you decide where you want to go, what do you have to know to get there? Librarians spend years learning how information is classified and sorted according to the conventions of a hundred disciplines and interest areas. What do they know that we all need to know? And how can we represent the topography of information in ways that will make it easier for all of us to navigate around in it?

Without all these skills future citizens will be as disempowered as those who today cannot write, read, or use a library. These are the necessary skills of our future literacies, those we will all need. But new information technologies also open up possibilities for extending our literacies in other ways, and many of us will choose to develop additional kinds of literacies that perhaps not everyone will need, but which will confer great benefits on those who acquire them. I discuss below two potentially important categories of such 'value-added' literacies: quantitative-mathematical literacy and cross-cultural literacy.

Typological and topological meaning

Analyzing multimedia semiotics has led me to ask some old questions in new ways and to begin to see the history of writing, drawing, calculating, and displaying images visually in a different light (Lemke 1994a, 1997a). I am coming to believe that we make meaning in two fundamentally complementary ways: (1) by classifying things into mutually exclusive categories and (2) by distinguishing variations of degree (rather than kind) along various continua of difference. Language operates mainly in the first way, which I call typological. Visual perception and spatial gesturing (drawing, dancing) operate more in the second, topological way. As I've already argued, real meaning-making generally involves combinations of different semiotic modalities, and so also combinations of these two rather general modes. The semantics of words in language is mainly categorial or typological in its principles, but the significant visual distinctions in handwriting (e.g. writing more 'boldly' or in slightly larger letters) or calligraphy, or the acoustic effects of speaking a bit more loudly or forcefully, make sense along a continuous spectrum of possibilities, 'topologically'. (In mathematics, topology studies matters of relative nearness, connectedness, continuity, etc.) Even in specialized subject areas like science, mathematics, art or music, the educational curriculum has followed the logocentric tradition in emphasizing conceptual categories and semantic distinctions, and neglected to educate students about topological principles of making meaning by creating and interpreting differences of degree as well as differences of kind. I believe that the new multimedia technologies will make the salience and importance of topological kinds of meaning far greater, and that an emphasis on these two complementary modes of meaning-making may help students grasp kinds of meanings (e.g. those based in quantitative and mathematical reasoning) that have tended to elude many of us in the past.

What is it that pictures, drawings, diagrams, graphs, tables, and equations do for us that verbal text alone cannot? What can we do far better still with combinations of texts and these other media? What is it exactly about a picture that even a thousand words cannot say as well? or about a diagram and its

caption that tell us far more than a drawing or a text alone could do? Why has natural science chosen to speak so often in the language of mathematics? And is mathematics really 'a language'? Should mathematical and quantitative literacies be considered integral parts of a multimedia literacy for today and tomorrow?

To answer these questions it helps to distinguish these two rather different kinds of meaning, or strategies for making meaning, that all human cultures seem to have evolved. We make meaning by contrasting types or categories of things, events, people, signs. For instance, we distinguish right from left, up from down, male from female, fruit from vegetable, motion from rest, red from blue, x from y, ahh from ohh, buying from selling, live from dead, writing from drawing. This is the basis of the semantics of natural language, and of the analogous representations of identifiable types, kinds, categories, qualities, etc. in other media. Most are based on a logic of either-or. Within a category we can often distinguish and contrast many different subcategories, and so on to great 'delicacy' of typological categorization and description. Our verbal sentences construct a small number of semantic relations among categorial processes, participants, and circumstances (cf. Halliday, 1985; Martin, 1992), and from this comes our conceptual reasoning. But this is not the whole story of human meaning.

Some of these categorial distinctions also allow differences by degree, so that there is now a possibility of intermediate cases that are in some measurable or quantitative sense 'in between' others: higher and lower, nearer and further, faster and slower, more reddish orange. But there is nothing which is in between motion and rest, living and dead; no mix of the letters x and y. Language does recognize difference by degree, but has very few and quite limited resources for describing such differences. Other forms of meaningful human action however are wonderful at indicating shades of intermediate degree: the rise of an eyebrow, the tension in a voice, the breadth of a gesture, the depth of a bow. Space and time; movement, position, and pacing define for us the possibility of meanings that are more topological, matters of degree, of almost-the-same, and just-a-bit-more-or-less, of what is like because it is near to or almost equal to, rather than like because it does or does not possess certain criterial properties for membership in a category, for being of some type. Typological and topological meaning are complementary in many fundamental ways.

Because language is so heavily biased toward the construction of typologically-grounded meanings, it requires complementary partners which are better at constructing topological meaning, especially when what we are trying to make sense about is a phenomenon which changes in important ways by degree. You cannot readily describe in words the shape of a draped bolt of fabric, but you can gesture that shape and you can draw it (if you've learned the skills). If the shape represents data on the pressure at different places inside a nuclear reactor system, it's not good enough to say the pressure is increasing very quickly near the containment dome: you want to measure the rate of increase and extrapolate it graphically or algebraically.

Many cultural phenomena seem to be strictly typological, but topological or quantitative analysis can undermine this illusion (e.g. biology finds no quantitative basis for racial categories). Other phenomena (like the phonemes of our native language) we learn to perceive typologically, even though a topological or quantitative analysis may be hard pressed to see how (e.g. the acoustic spectra of language sounds on an oscilloscope screen don't neatly fit phoneme categories, so you can't 'see' where particular letters or even whole syllables begin or end -- and sometimes can't see them at all). Many natural phenomena however yield rather directly to analysis by degree, in space, in time, in movement or change, in mass, in temperature, and in all the other quantitative 'variables' that science has found so useful.

Our concepts tend to depend on the typological semantics of language or other media of representation, but our experience in the world as material bodies in space and time interacting with an environment shows us the importance of topological meaning as well. It is no accident that the most systematic

extension of natural language into topological domains of meaning, known to us as mathematics, has arisen historically as a kind of bridge between conceptual language and quantitative measurement and description. Or that mathematics has been built from both sides: from language through arithmetic to algebra and functions, and from continuous variation in the environment to visual depiction to geometric diagrams and Cartesian graphs. The modern unification of algebra and geometry is only one chapter in the long history of the semiotic integration of typological and topological meaning.
Many people experience great difficulty with quantitative and mathematical reasoning, beginning from just those points where, historically, mathematics went beyond what natural language could comfortably deal with, inventing notions like complex ratios and fractions, partially compensating operations and reciprocal-inverses, continuously varying functions and equations with multiple factors and operations. Natural language has no problem with integers, with simple fractions or ratios, with addition and subtraction. It can just barely get around multiplication, and begins to give up with division. Many mathematical concepts which are confusing or resist easy explanation and learning in natural language alone become far clearer with visual representations and manipulatives combined with natural language. It is not a matter of substituting one for the other, but of combining them together: conceptual typological reasoning and quantitative topological accounting.

Not every aspect of human cultural life yet requires sophisticated quantitative and mathematical reasoning. It is not yet part of the literacy skills of most non-technical genres. For many purposes the combination of visual-image representations, including abstract ones like graphs and tables, and verbal ones is sufficient. But I suspect that extending multimedia literacy to include mathematical representations could become much easier with new information technologies. Expanded use of and familiarity with visual representations will make it easier for students to deal with quantitative relationships expressed also in more formal mathematical terms (numerical or algebraic). If the time comes when a new generation's multimedia literacy is as much at home with quantitative reasoning and representation as with depiction and verbal text, then ideological oversimplifications based purely on category names, like White vs. Black, Straight vs. Gay, Masculine vs. Feminine will be vulnerable to quantitative deconstruction for far more people than the few technical specialists who understand these arguments today.

The cultures, attitudes, and characteristics of real people have never fit the pigeonhole categories of our typologies and stereotypes. Too many real people have claims, to some degree and in some ways, to fit both sides of these dichotomies, to be members of many categories whose names and definitions make them seem mutually exclusive. Our lived realities cannot be faithfully represented in purely typological ways; too many people have no voice where there are no other ways to make sense. The topological potential of multimedia literacy can help give voice, dignity, and power to real hybrid people. It can undermine an ideological system that limits personal identities to a few available and approved social pigeonholes and let us see and show one another the much larger multidimensional universe of real human possibilities.

Global Cultural Literacies

Information exchange, academic and business collaboration, even entertainment and shopping, are very soon going to be much more global, and cross-cultural, than ever before in human history. The dominance of cyberspace by the Euro-American cultural tribes will inevitably be short-lived. Asian societies have the technology and the confidence in their cultural traditions to ensure that global exchange will not take place entirely on our terms, as it has for the past couple centuries. We may not welcome the loss of our economic hegemony, and our impossibly exaggerated standard of living relative to the rest of the world's population, but we should certainly welcome new ways of making meaning. English may or may not survive as the 'lingua franca' of the internet (a lot depends on whether machine translation ever becomes effective, fast, and cheap), and although it wouldn't hurt Americans particularly to learn a non-Indo-European language with a non-alphabetic script, what

seems most likely is that non-European traditions of visual design and esthetics, e.g. Asian-European hybrids in multimedia, will become extremely important to the evolving genres of cyberspace. In time other cultural traditions will join the mix in substantial ways as well, as African-European cultural hybrids already have in music and visual arts styles.

Increasingly, members of our on-line communities are going to come from non-Euro-American cultural backgrounds. We are going to have to learn to communicate effectively with them, and to learn effectively from them. Our economic success, our intellectual opportunities, and perhaps the longterm cause of world peace and harmony, depends on our success in this. Because we have been on top for so long, it will be harder for many upper-middle-class Americans and Europeans to learn how to listen across cultural differences. Most of the rest of the world has long since had to learn how to listen to us.

As we face the many tasks of communication and design, of combining and integrating text with graphic images both abstract and iconic, not to mention animations, videos, sound, and so forth, we will want to consider all the resources, all the traditions, all the possibilities in the human repertoire. And we will need to do this as the next phase of world cultural evolution speeds up. We will be moving beyond the era of national and ethnic cultures to an era of diverse cultural hybrids, each with a global community of members and afficionados. The new world cultural order will be no less diverse and complex than our present one, but its basis will extend beyond geography and family heritage to encompass shared interests and participation in activity-centered communities (see examples in Tierney & Damarin, this volume).

The global human heritage provides more than just geo-cultural diversity as a resource for new ways of making meaning: it also provides the historical diversity within each of our cultural traditions. Visual and textual forms and the conventions for combining them have passed through many interesting historical turns, some of them largely lost to present-day awareness. The study of the history of semiotic media is likely to become an increasingly important part of scholarship, and a richer resource in the curriculum. In my own work I have been greatly impressed by what can be learned from the rich resource of a comprehensive, global history of mathematical notations (Cajori, 1928), or from the growing literature on the history of visual representations in many fields (e.g. Alpers, 1983; Bellone, 1980; Eisenstein, 1979; Skelton, 1958; Tufte, 1983, 1990; see also Olson, 1994, chapter 10).

Vast as this underappreciated literature is, there is more still on the representational conventions of non-Western cultures. Both Western and non-Western media history are likely, in my opinion, to richly reward study, appreciation, and appropriation for the purposes of constructing and teaching our future multimedia literacies.

These then are the key directions for transformation of our contemporary literacies as we enter the Information Age: we certainly need generalized multimedia and informatic literacy skills now, and we will probably also need more quantitative-topological and more global-historical literacies for the near future.

Transforming Learning Paradigms

With so much to be learned, we need to give some thought to how new information technologies may transform our institutional habits of teaching and learning. There are two paradigms of learning and education contending in our society today, and the new technologies will, I believe, shift the balance between them significantly (Lemke 1994b).

The curricular learning paradigm dominates institutions such as schools and universities. The curricular paradigm assumes that someone else will decide what you need to know, and will arrange for you to learn it all in a fixed order and on a fixed schedule. This is the educational paradigm of industrial capitalism and factory-based mass-production. It developed simultaneously with them, and in close philosophical agreement; it feeds into their wider networks of employment and careers, and resembles them in its authoritarianism, top-down planning, rigidity, economies of scale, and general unsuitability to the new information-based 'fast capitalist' world (see below). It is widely refused and resisted by students, and its end results provide little more of demonstrated usefulness in the non-academic world than a few text literacies and certification as a member of the middle class.

The interactive learning paradigm dominates such institutions as libraries and research centers. It assumes that people determine what they need to know based on their participation in activities where such needs arise, and in consultation with knowledgeable specialists; that they learn in the order that suits them, at a comfortable pace, and just in time to make use of what they learn. This is the learning paradigm of the people who created the internet and cyberspace. It is the paradigm of access to information, rather than imposition of learning. It is the paradigm of how people with power and resources choose to learn. Its end results are generally satisfying to the learner, and usually useful for business or scholarship. It is perhaps also the paradigm of 'fast capitalism' (Gee 1996, Lemke 1997a), in which economies based on the production and circulation of information favor rapidly changing workgroups of flexible individuals engaged in projects that produce 'just-in-time' results for niche-market customers. And it may tend to produce less 'common learning' among the members of a society, and favor specialization over liberal arts education.

These two educational paradigms are in fundamental conflict, and many disappointments that schools are not more eager to adopt computer-mediated information technologies may perhaps be laid at the door of this largely unrecognized conflict (Hodas 1994).

The curricular paradigm is failing disastrously in America today. Anyone who has spent time in urban schools, even the better ones, can tell you that things are even worse than standardized tests and statistics tell. Most students really don't see the usefulness of most of what they are being expected to learn. Many know they are unprepared for what they are scheduled to learn this year. The nation is trying to develop a national curriculum at a time when only the most rudimentary elements of school-based learning (say up to grade 8) are demonstrably of value to most citizens when they leave school, and when beyond that whatever some will use others will not need at all. We are trying to impose uniform learning at a time when there has never been more radical inequality of every kind among students of a given age. Fortunately, the institutional arrangements for schooling in the U.S. are so decentralized that a national curriculum in practice (as opposed to agreements in principle) seems unlikely ever to actually happen. I believe that the effort to create a uniform content-centered national curriculum may in fact seriously hamper our transition to more effective and appropriate educational models for the globally competitive future.

What seems to be generally agreed among educators and many citizens and prospective employers is that we want people, of whatever age, who can guide their own learning, who know enough to know how to learn more, including where and to whom they should turn for useful advice and relevant information. We want people who know things that they want to know, and people who know things that are useful in human enterprises outside schools. We want people who are at least a little critical and skeptical about information and points of view, and have some idea how to judge their reliability. But beyond this there is no general social consensus about the content of education beyond what could be learned in the first eight or nine years of schooling, and there is no basis in empirical research for deciding what every citizen would actually find it useful to know after leaving school. My personal view is that if such research were done it would not find much of anything universally necessary beyond what could be taught in those basic years. It is perhaps time that we put behind us the American preoccupation with nation-building and common culture. We are indissolubly tied together

by our interactions with and interdependencies on one another, and it really does not matter, except for ideological purposes, how much alike we are or are taught to pretend we are.
Every effort to construct a common curriculum is an effort by some people to impose their values on others who probably don't agree. Only demonstrated necessity or substantial usefulness to most people can morally justify curricular uniformity, especially in the context of a coercive educational system (i.e. one where participation is not voluntary, and resistance is punished by sanctions that go beyond the inevitable consequences of our own actions). It is particularly morally questionable that curricular education is imposed on the weakest members of our society: those who are forbidden many political and legal rights of all other citizens, solely because of their age.

Fully empowered adults would not tolerate the faults of many of our schools: their authoritarianism, their educational incompetence, their inadequate resources, their physical conditions. The very young may have little choice about their helplessness; they cannot yet operate the machinery of our complex society at even the most basic levels. We cannot empower them. But from an age somewhere between 10 and 13 years depending on the individual (and governed at least a little by the extent of opportunities afforded), we know that increasing numbers of younger citizens can exercise adult rights and want to, but are not permitted to, and are prevented from doing so by law and by force.

It is arguable that the curricular paradigm survives in our schools mainly because of, and perhaps in part in the service of, the political domination of citizens in their second decade by older and more powerful adults.
New information technologies will make it possible for students to learn what they want, when they want, how they want, without schools. Not all students will have equal or even immediate access to these technologies (cf. Bruce & Hogan, this volume), but those who do will surely see the possibilities. Curricular education will not be able to compete, for sheer educational effectiveness or economic efficiency, with the learning services that will become available on-line and in portable media for interactive education. The interactive paradigm need not be one of isolated learning, nor even of exclusively computer-mediated learning. Social interaction among peers, and between learners and mentors and other experts, will take place on-line, one-on-one and in groups of various sizes. Some of this interaction will be live in real time, and some will be asynchronous, as with listservers and newsgroups. Face-to-face groups will still play an important role, as will direct interaction with teachers. But the proportions of time spent in each of these learning modes will change radically, and the diversity of approaches to learning will increase (Garner & Gillingham, this volume). 12

What will necessarily be radically different, however, is the single issue of control. In the interactive paradigm students will pursue topics and interests and problems and agendas of their own and of the groups they participate in. They will encounter the fundamental categories, concepts and principles of all the basic disciplines, whatever trails they blaze through the forests of knowledge, precisely to the extent that these notions really are fundamental and widely applicable and therefore necessarily to be found wherever we travel. But they will all fashion for themselves essentially different educations, with only that degree of commonality that arises from interaction with others and from the common usefulness of common notions.

The interactive learning paradigm, once its information technology infrastructure is in place, will also very likely be a lot cheaper than the present schools-and-curricula arrangements. We will not need a separate material infrastructure for education nearly to the extent that we do today; education will be one function of a multi-purpose technology. We will not need to buy all the working time of so many teachers, but only to compensate sufficiently the people who make themselves available to students on-line, and the few specialists who will staff more specialized learning facilities. Those who produce great interactive learning environments will be well paid by the marketplace. A great deal of productive labor potential now tied up in chalking-and-talking curricula to captive classroom audiences will be liberated to enrich the general information economy.

What will be the new information technologies that can best support an interactive learning paradigm and make use of those multimedia and informatic literacies that will genuinely be needed by everyone?

Transforming Technologies: Toward Meta-Media Literacies

The first generation of interactive learning technologies has mostly been, not unexpectedly, simply a transposition of the textbook model of education to a new display medium. Trees may be grateful, but little about the nature of learning changes, perhaps only the increased motivation for some students, generated by novelty. But as soon as on-line text becomes digital (as opposed to bit-mapped images of the page), it is easily searched. And if it can be searched, it can be indexed and cross-referenced. Now the text is also simultaneously a database, and hypertext is born (Nelson 1974, Landow 1992, Bolter 1991 and this volume). If we can use a word or phrase in the text as an index entry to find other occurences, and also add cross-references to other specific items in the same text, why not then make links to other texts? In the simplest cases, hypertexts offer us only one link per item, but there is no inherent limitation of this kind in the concept or the technology. If we can jump from one text to another, and to multiple landing points from each jumping-off point, we will need some navigational assistance in order to backtrack and to get a sense of the text-space we are mapping out and traversing. Since the topography of these links is non-linear, a two or three-dimensional image or map is a useful navigational tool. It can be established by an author and later customized or reconstructed by each reader.

Now learning changes. Instead of being the prisoners of textbook authors and their priorities, scope, and sequence, we are free agents who can find more about a topic they skimped on, or find alternative interpretations they didn't mention (or agree with, or even consider moral or scientific). We can shift the topic to match our judgments of relevance to our own interests and agendas, and we can return to a standard, textbook-like development later. We can learn as if we had access to all these texts, and as if we had an expert who could point out to us most of the relevant cross-references among them. We now have to learn to exercise more complex forms of judgment, and we get a lot of practice doing so. The next generation of interactive learning environments adds visual images and then sound and video and animation, all of which became practical when speed and storage capacity can accomodate these information-dense topological forms of meaning. 13

From the typological point-of-view, text has very low redundancy, it doesn't code in much more than is needed to make the key distinctions between one word and another, but visual images typically contain all sorts of typologically 'irrelevant' information -- which is for that very reason potentially critical to their topological meaning capacity. (Compression strategies need to be careful not to be overly biased toward preserving typological meaning at the expense of potentially valuable topological meaning. If you reduce the number of bytes allotted to Aunt Hilda's voice message as much as you could for her email message, you could probably still make out the words, but it wouldn't sound like Aunt Hilda anymore.) These more topological media cannot be indexed and cross-referenced for their internal content (what the picture shows, say) but must be treated as whole 'objects'. Even so, as objects they can become nodes for hyper-links, and so hypermedia is born (see Landow & Delany, 1991; Bolter, this volume). The importance of the corresponding multimedia literacies has already been discussed, but it is worth noting that it is not only using hypermedia, but authoring them that the new technologies make easier. Today anyone can edit audio and video at home, produce good quality animations, shape three-dimensional objects and environments, combine them with text and still images, add music and voice, and produce works far beyond what any publisher or movie studio could have done until a few years ago.

The key to interactive learning paradigms, however, is neither hyperlinks nor multimedia, but interactivity itself. Interactive media present themselves differently to different users depending on the user's own actions. This can be as simple as seeing one image rather than another after clicking on a link, but it becomes educationally useful to the extent that the result of the interactions accumulates intelligently, so that the whole history of my interaction with a program influences what it shows me when I click on that link. This is the basic principle of intelligent tutoring systems (ITS, see Wenger, 1987), a parallel development to educational hypermedia, but still mainly within the curricular paradigm. An ITS program constructs a 'model of the user' over time and customizes its responses to lead the user optimally to a fixed learning goal. Each different user potentially follows a different pathway, but all end up in the same place.

What would we get if we combined the dynamic user-customization of an ITS with the learning paradigm of exploring and navigating interactive hypermedia? The purpose of a user model then would not be to create a path to a fixed goal; goals would be emergent for the user as a result of interacting with the media. The user-model would catalogue where we'd been, our learning styles and preferences, our prior background in different subjects, and could offer us a filtered set of choices for each next jump or link which would optimize their potential value for us. The program could be set to offer narrow or wider ranges of choices, index the options by various criteria useful to us in making the ultimate choice ourselves, and include a certain percentage of serendipitous surprises. Like a human tutor, the program would 'get to know us', and in effect make suggestions to help us make the most of our time in cyberspace. It could tailor the text and images it generated to our needs (cf. Hovy, 1987). It would also need to be able to reconfigure information from one medium to another, to the extent that this is possible, varying the relative emphasis of text, voice, still images, videos, animations, and degrees of abstraction, either by selection from available items, or by conversion from one to another. This would, accordingly, be in fact a meta-media system.

With such a technology we could be free to learn in the language and dialect of our choice, with the visual-esthetic styles of our choice, and the mix of media we learn from best. Just as various document definition languages (such as SGML, HTML, and VRML; Hockey 1996) allow different browsers to customize how they present the same text and image files, one can imagine our meta-media system's source files to contain data in abstract representations that could be variously displayed as text, chart or table, graph, diagram, visual image, video, etc. (cf. Arens, Hovy, & Vossers, 1992) according to user preference and ITS 'tutor' recommendation.

Original source media are thus going to be re-linked and their displays transformed endlessly by different individual and group users who are sharing files. Systems will need to keep track of user annotations and overlays (backing-up earlier versions), user-added links, user transformations of medium, user-defined sequencings, etc. so that any original source file or complete metamedia work will exist in many customized versions, each with a traceable history. Some of these versions will conceivably become more popular with new users than the originals, and some may come to be recognized as 'classics', even as all of them get endlessly modified. Various user communities will determine what constitutes 'value-added' in this process, and what is transient or idiosyncratic. Intelligent metamedia tutoring systems will, of course, have to be able to sort through the many available versions as they seek optimization for their user. Users will inevitably gain some sophistication in this process as well, as they provide the 'tutor' with explicit instructions and responses to queries, as well as statistical patterns of past and continuing choices, to which the tutoring program will be sensitive.

Transforming Humanity

The ultimate display medium is reality itself: what we see and hear, touch and feel; what we manipulate and control; where we feel ourselves to be present and living. Our bodies are integral parts of larger ecosocial systems: we live in those systems materially as sensory signals and motor feedback, heat exchanges and nutrient/waste flows link us into them; and we live in them semiotically as we make culturally and personally meaningful sense of our participation. Reading a text, our verbal and visual imaginations can begin to conjure a second world of meanings in addition to the usual realistic ones. Watching a film on a large screen, the divergence between sense-data and fictional illusion diminishes; we can experience terror or a sensation of falling while watching a fabric screen and sitting in a fixed chair. It is possible to intercept many of the signals by which our bodies locate themselves in space, time, and reality and replace them by other signals. To do this we have to monitor our actions and efferent motor signals as well as supply new inputs, because our bodies create reality out of the relationship between outgoing efferent and incoming afferent nerve impulses. A fast enough computer can simulate reality well enough to fool a large part of our body's evolved links with its environment. We can create virtual realities, and we can feel as if we are living in them. We can create a sense of full presence (cf. Benedikt, 1991; Rheingold, 1991).

Within a virtual reality (VR) environment, all other media can be presented and coordinated. What VR technologies add is greater interactivity: we can make more things happen in VR worlds, and that is partly why we feel that they are more real. But they do not have to happen according to the laws of normal physics, or the constraints of our normal ecological environment, provided the timing of action and reaction is precise enough to make them seem equally real. In principle in VR we can learn by doing, without consuming proportional material resources as we would in the normal world, without the attendant risks to life and limb, or the consequences to our life-sustaining ecosystem. And we can do what is simply not normally possible: we can change reality by acts of will or small motor commands, we can be the sorcerers of our dreams and our nightmares.

We can also learn to be a different sort of human being (Lemke 1993b). We can walk, not through a simulated Martian valley, but by telepresence and a robot-sensor system, on the actual surface of Mars. We can sound with whales and soar with eagles. We can observe the earth from space in real time, and zoom in to any place that is visible and monitored. We can observe on our normal human time-scale the changes in a rainforest over decades as seen from space. We can burrow with insects. We can grasp biological molecules and do chemistry by hand as the molecules react according to their quantum laws. We can expand the scale of direct human experience in space and time to the limits of our technology. And we can do all these things as children.

What kinds of humanity are possible for us if we can learn in these ways? have these experiences from our childhood? What are the possibilities, and what are the dangers?

The literacies of VR converge with, and indeed go beyond, the literacies and wisdoms of human life itself. What is a 'literacy' when the distinction between 'reading' and living itself is nominal? when a 'reality' becomes our multimedia text, enhanced by the sorcery of hyperlinks that can carry us not just from page to page or text to text, but from place to place, from time to time, and from the cosmological scale to a world of quarks? Is this dream or nightmare?

Yes, we could become lost in this cyberspace. Not for want of navigational aids, but because we may prefer the worlds of our own imaginations to those within which we evolved. Literacy confers both power and vulnerability: the power to add a second meaning-world to the one our bodies are enmeshed in, but also the vulnerability of mistaking the former for the latter. The power comes when we add one to the other; the danger if we substitute virtual for ecological reality. The semiotic capacity of human beings makes us infinitely adaptable in terms of the meanings we attach to our experience, but not all of those possible adaptations will allow our species to survive. In the lifetimes

of students now in our schools, these issues will have to be faced. Will the literacies we teach today help them choose wisely?

No one can predict the transformations of 21st-century society during the information technology revolution. We certainly cannot afford to continue teaching our students only the literacies of the mid-20th century, or even to simply lay before them the most advanced and diverse literacies of today. We must help this next generation learn to use these literacies wisely, and hope they will succeed better than we have.

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